FIG.1

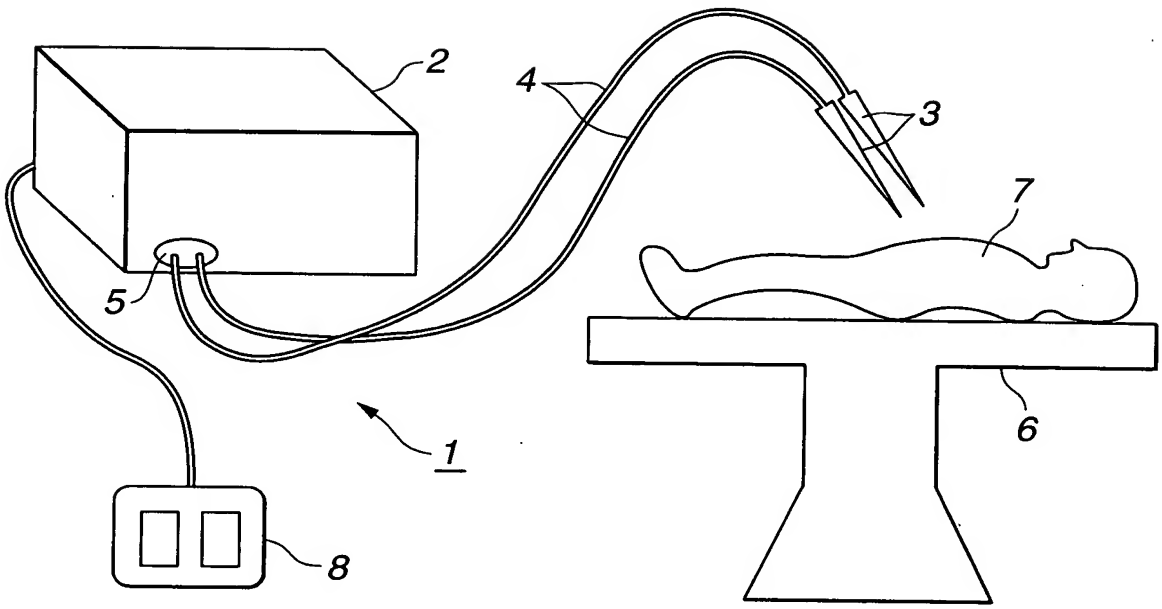


FIG.2

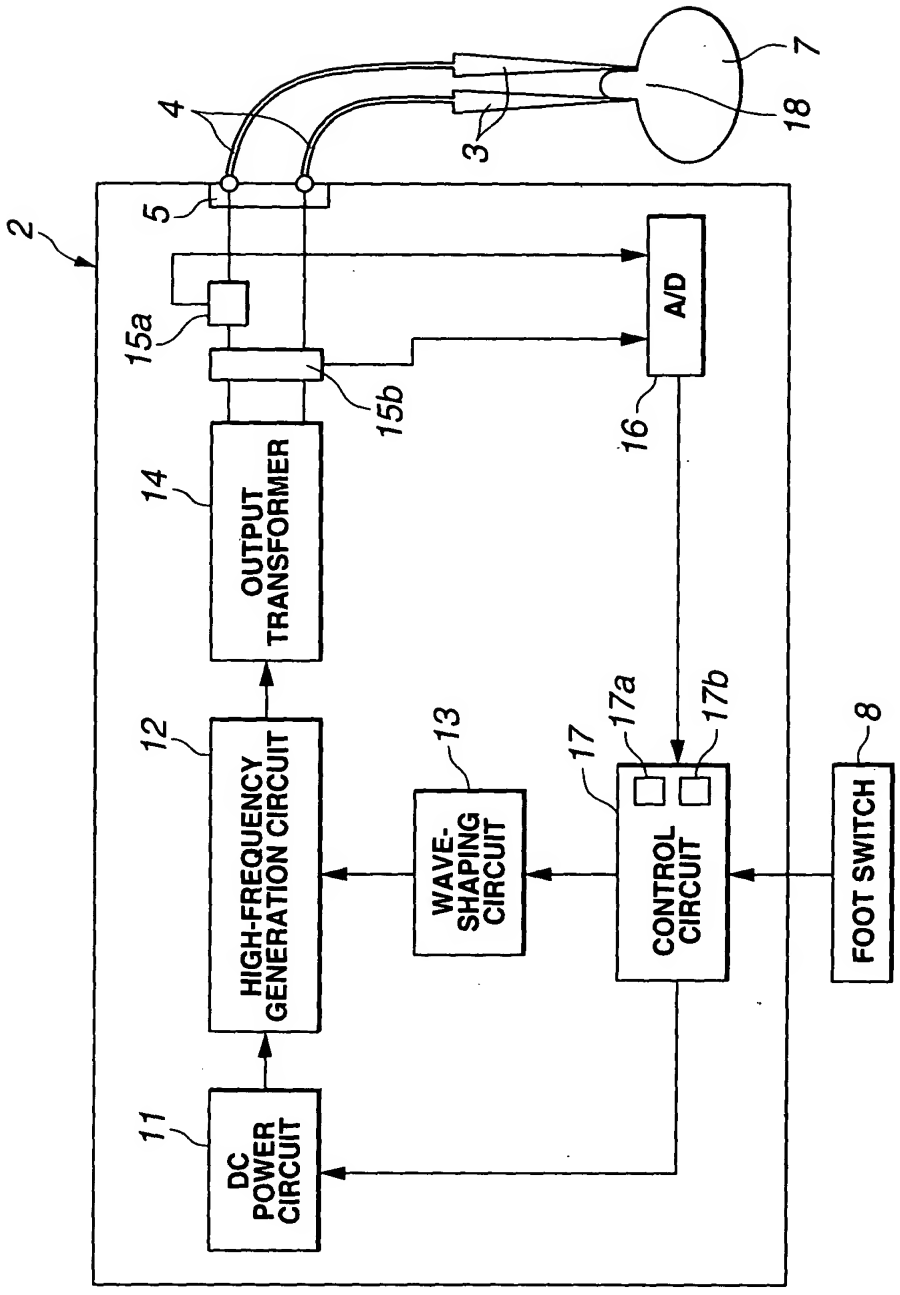

2
4
3
7
18
5
15a
15b
A/D
16
14
OUTPUT TRANSFORMER
12
HIGH-FREQUENCY GENERATION CIRCUIT
13
WAVE-SHAPING CIRCUIT
17
17a
17b
CONTROL CIRCUIT
8
FOOT SWITCH
11
DC POWER CIRCUIT

FIG.3

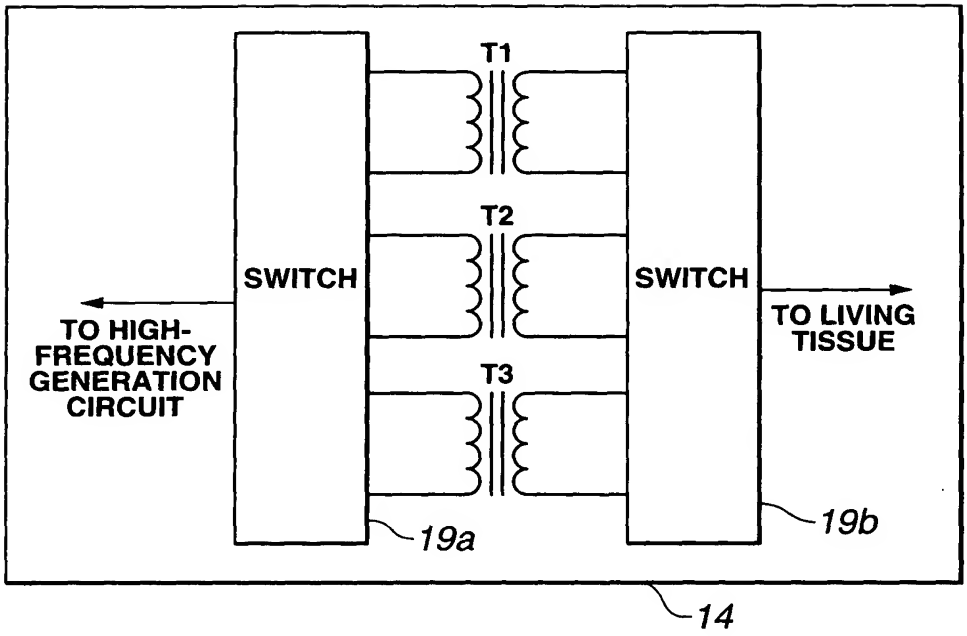

T1
T2
T3
SWITCH
SWITCH
TO HIGH-FREQUENCY GENERATION CIRCUIT
TO LIVING TISSUE
19a
19b
14

FIG.4

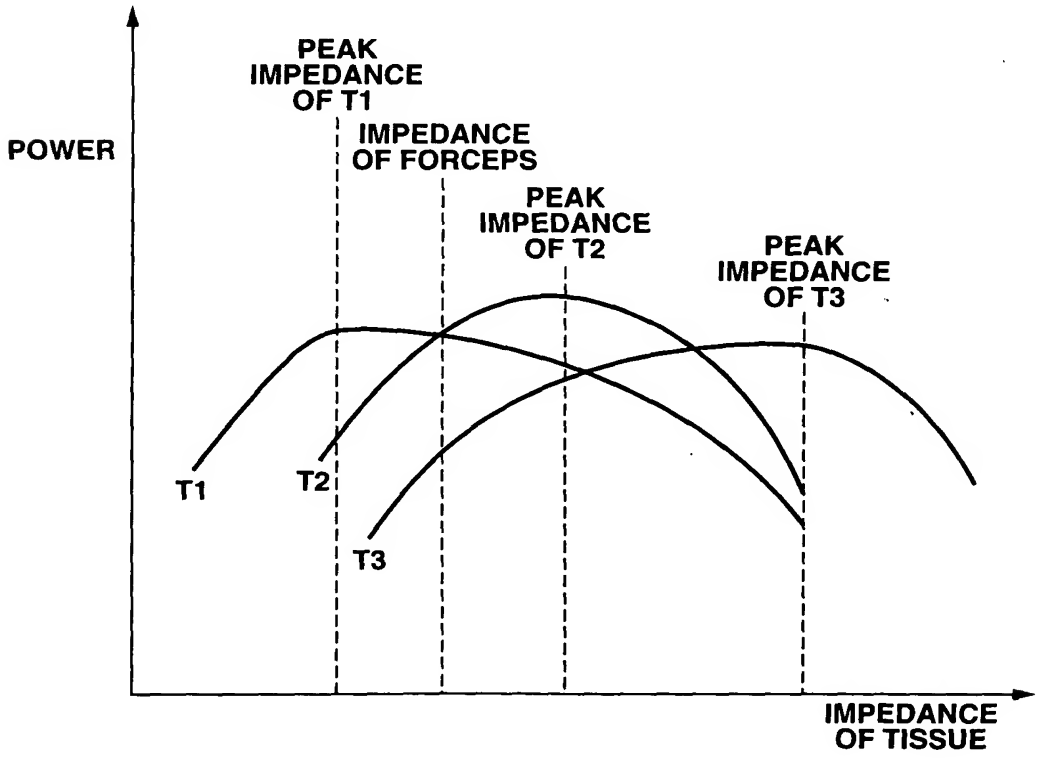

POWER
PEAK IMPEDANCE OF T1
IMPEDANCE OF FORCEPS
PEAK IMPEDANCE OF T2
PEAK IMPEDANCE OF T3
T1
T2
T3
IMPEDANCE OF TISSUE

FIG.5A

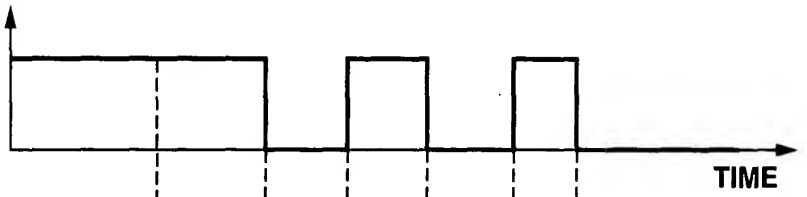


FIG.5B

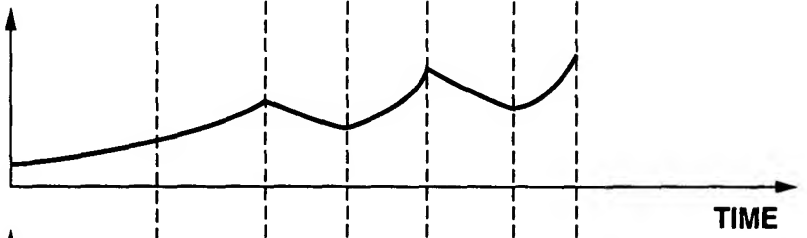


FIG.5C

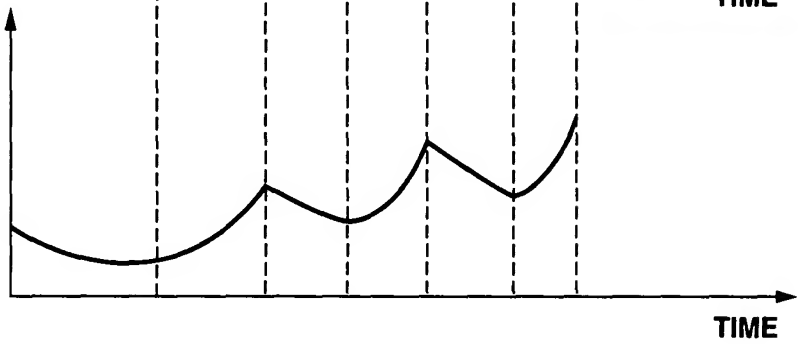
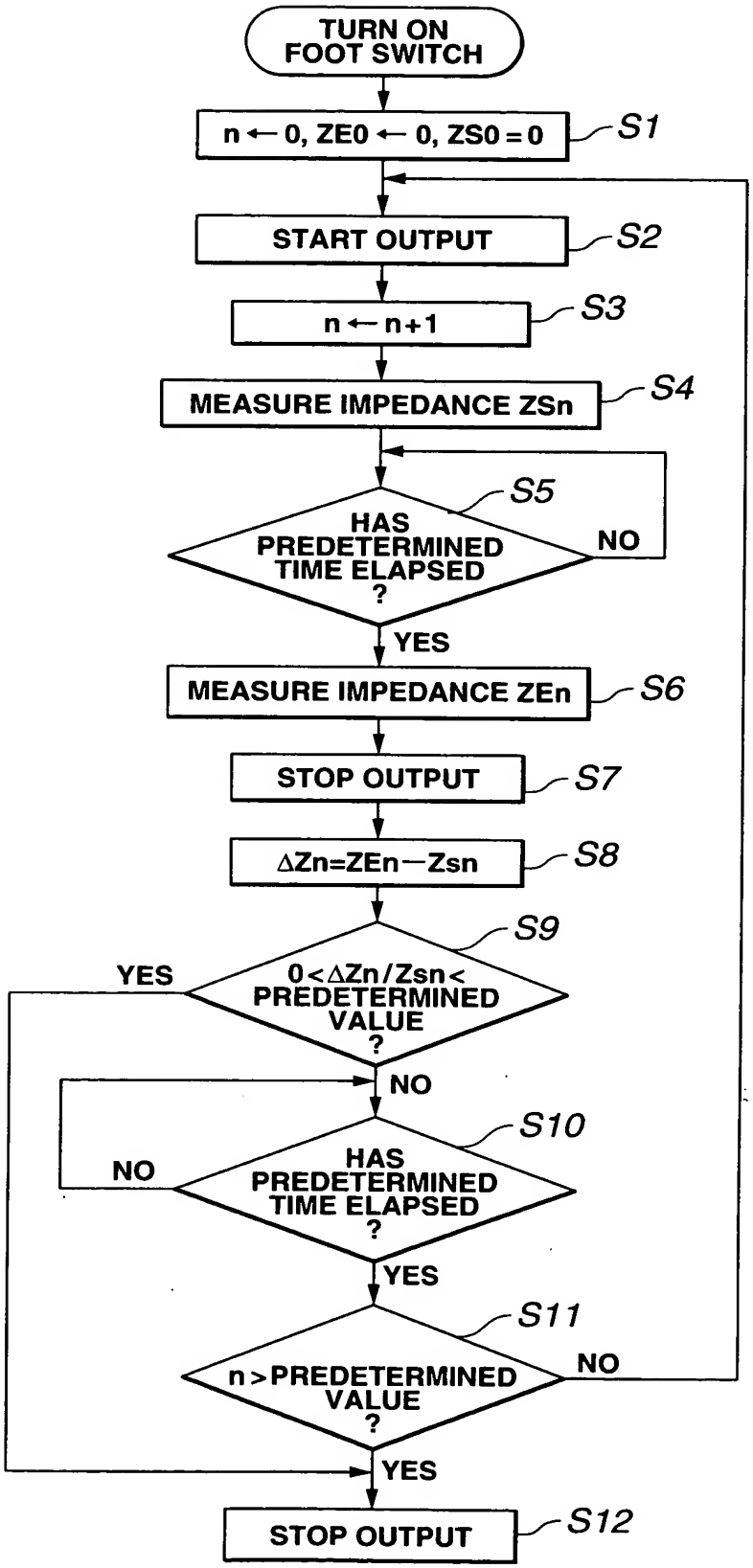


FIG.6


TURN ON FOOT SWITCH
n ← 0, ZE0 ← 0, ZS0 = 0
S1
START OUTPUT
S2
n ← n+1
S3
MEASURE IMPEDANCE ZSn
S4
HAS PREDETERMINED TIME ELAPSED ?
S5
NO
YES
MEASURE IMPEDANCE ZEn
S6
STOP OUTPUT
S7
ΔZn=ZEn−Zsn
S8
0<ΔZn/Zsn< PREDETERMINED VALUE ?
S9
YES
NO
HAS PREDETERMINED TIME ELAPSED ?
S10
NO
YES
n>PREDETERMINED VALUE ?
S11
NO
YES
STOP OUTPUT
S12

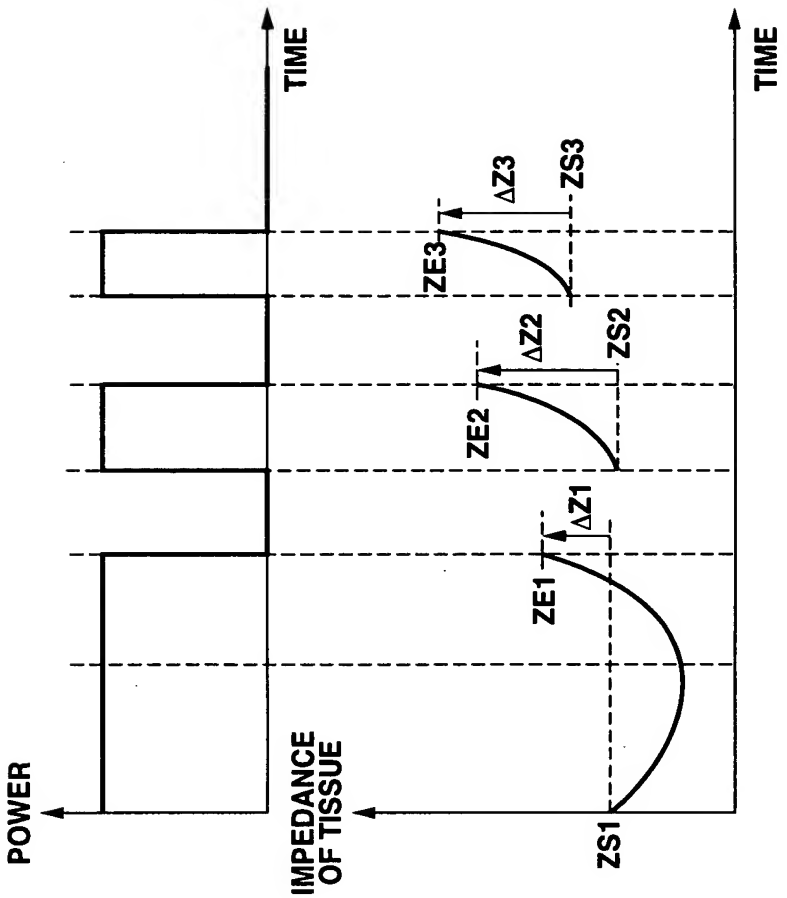

POWER
TIME
IMPEDANCE OF TISSUE
TIME
ZE3
ΔZ3
ZS3
ZE2
ΔZ2
ZS2
ZE1
ΔZ1
ZS1

FIG.7A

FIG.7B

FIG.8A

FIG.8B

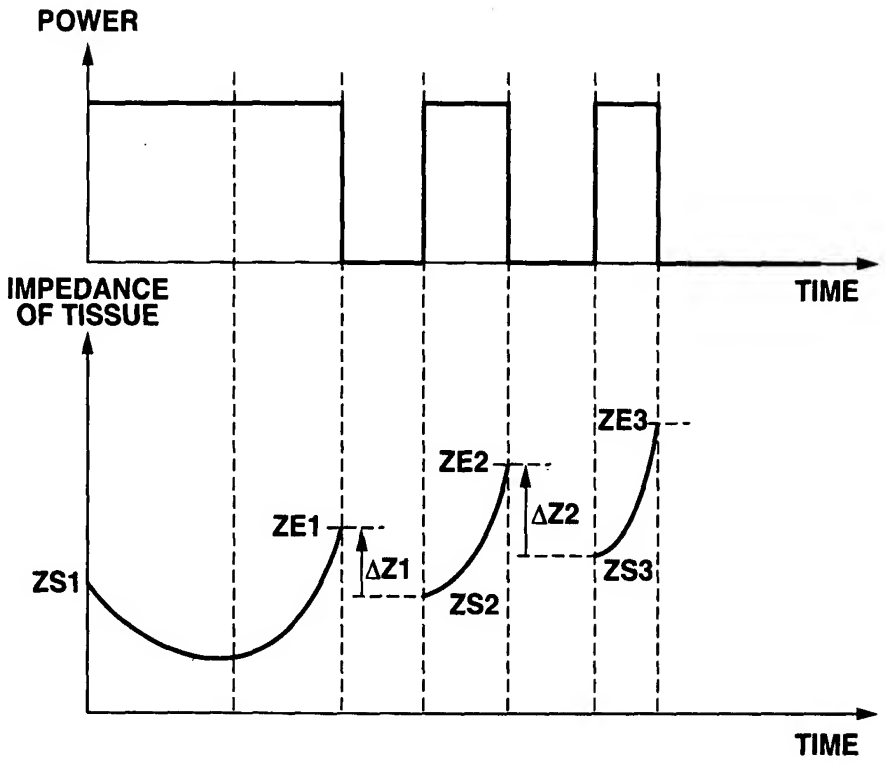

POWER
TIME
IMPEDANCE OF TISSUE
ZE1
ZE2
ZE3
ΔZ1
ΔZ2
ZS1
ZS2
ZS3
TIME

FIG.9A

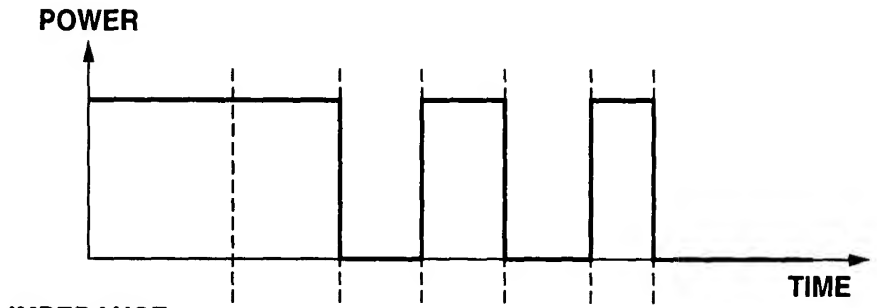


FIG.9B

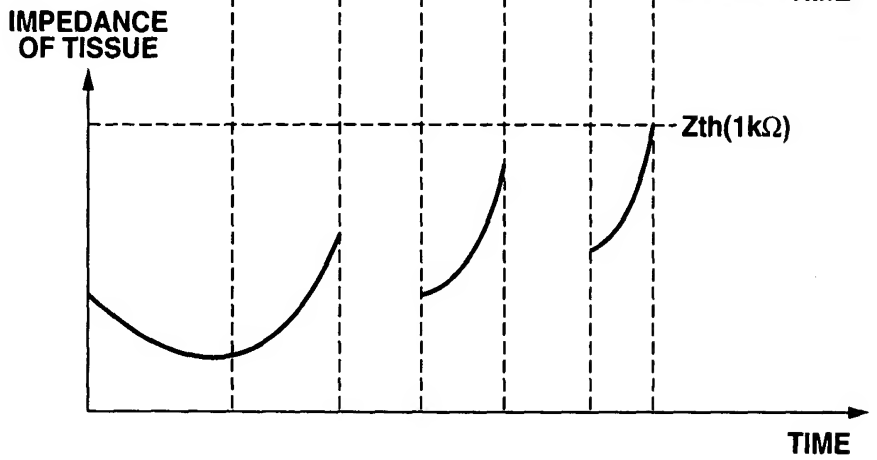


FIG.10

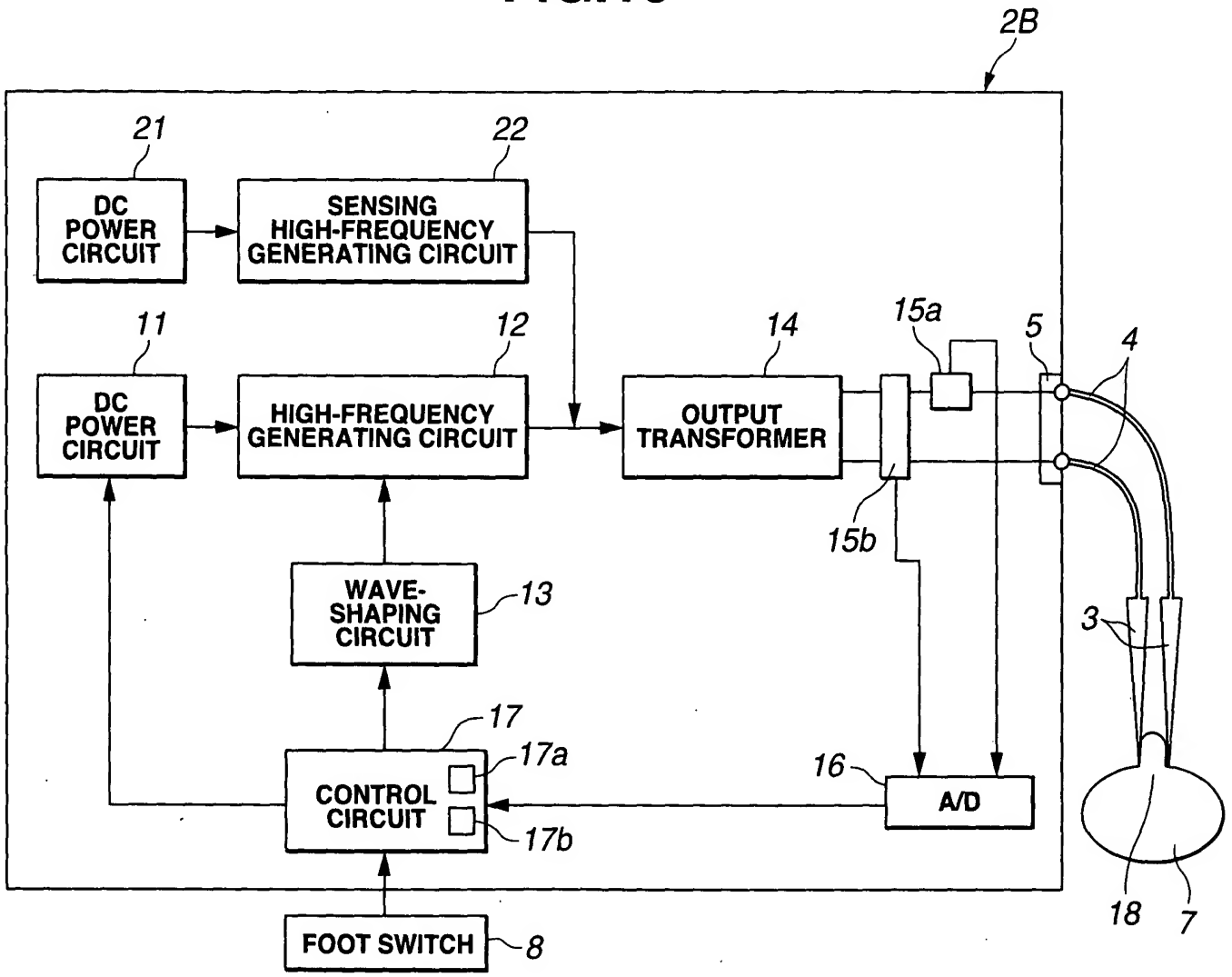

2B
21
22
DC POWER CIRCUIT
SENSING HIGH-FREQUENCY GENERATING CIRCUIT
11
12
14
15a
5
4
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATING CIRCUIT
OUTPUT TRANSFORMER
15b
WAVE-SHAPING CIRCUIT
13
3
17
17a
16
CONTROL CIRCUIT
A/D
17b
18
7
FOOT SWITCH
8

FIG.11

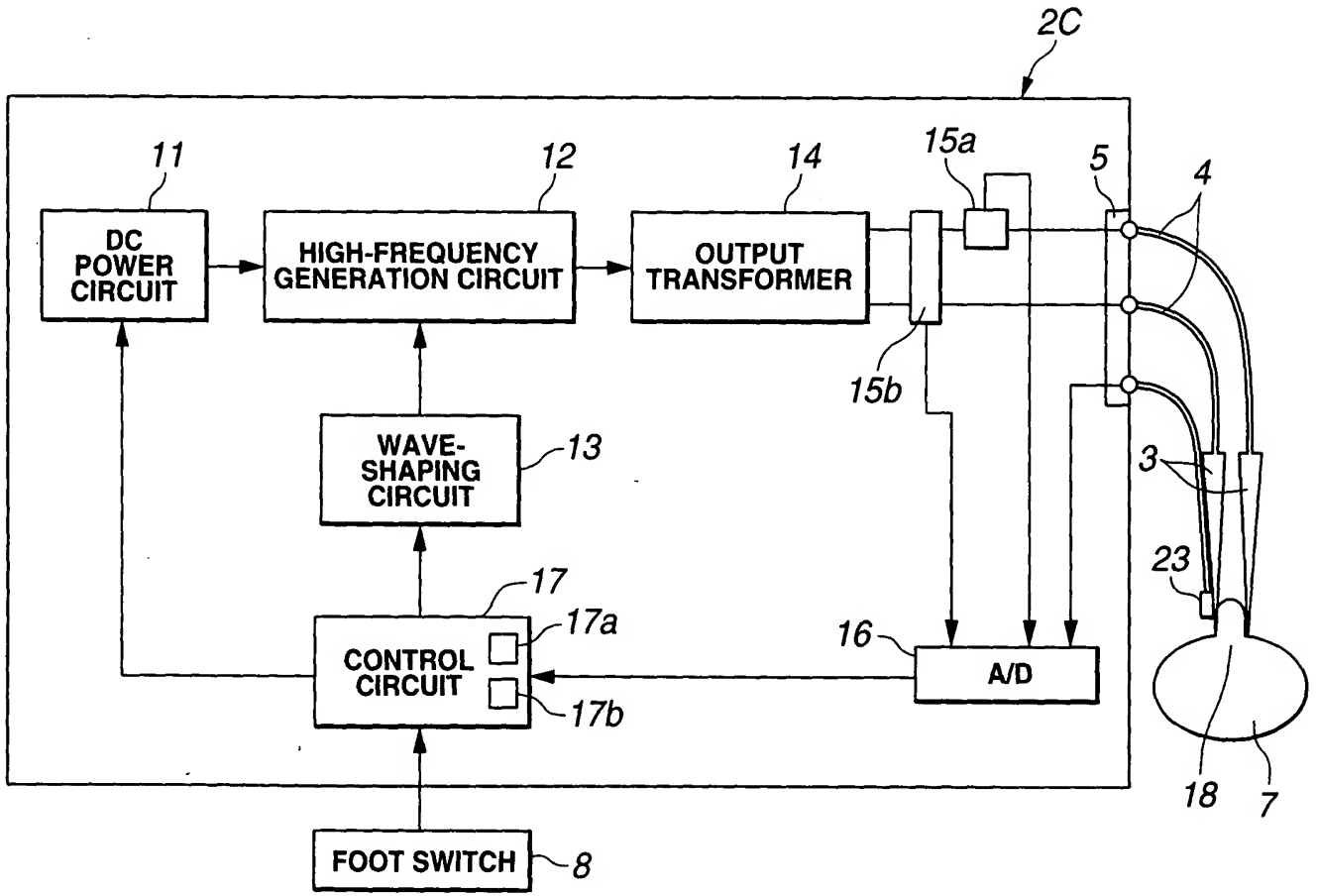

2C
11
12
14
15a
5
4
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
15b
WAVE-SHAPING CIRCUIT
13
3
23
17
17a
CONTROL CIRCUIT
16
A/D
17b
18
7
FOOT SWITCH
8

FIG.12A

FIG.12B

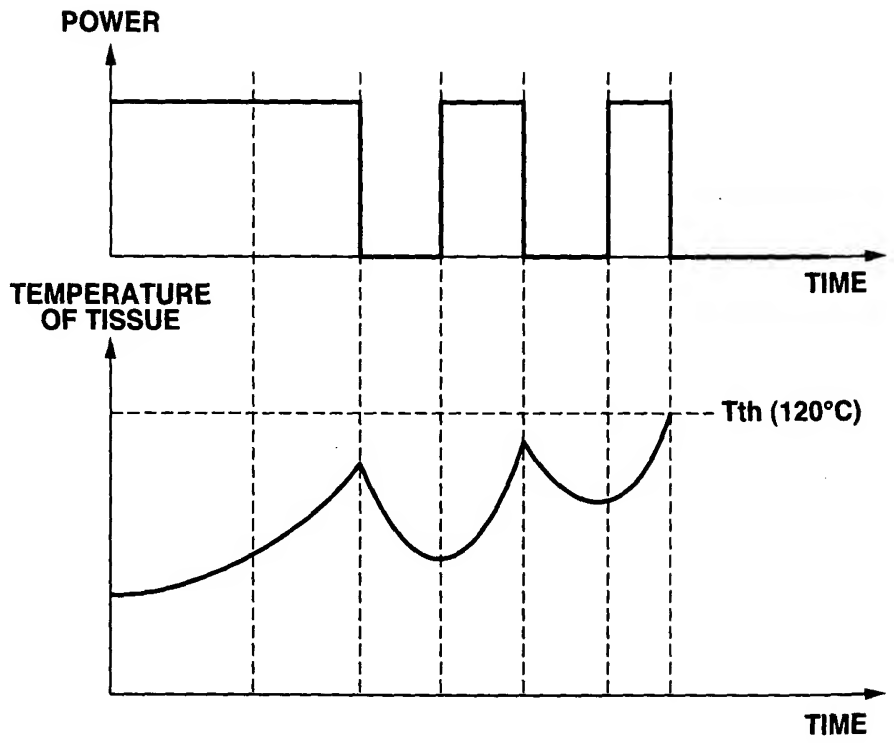


FIG.13

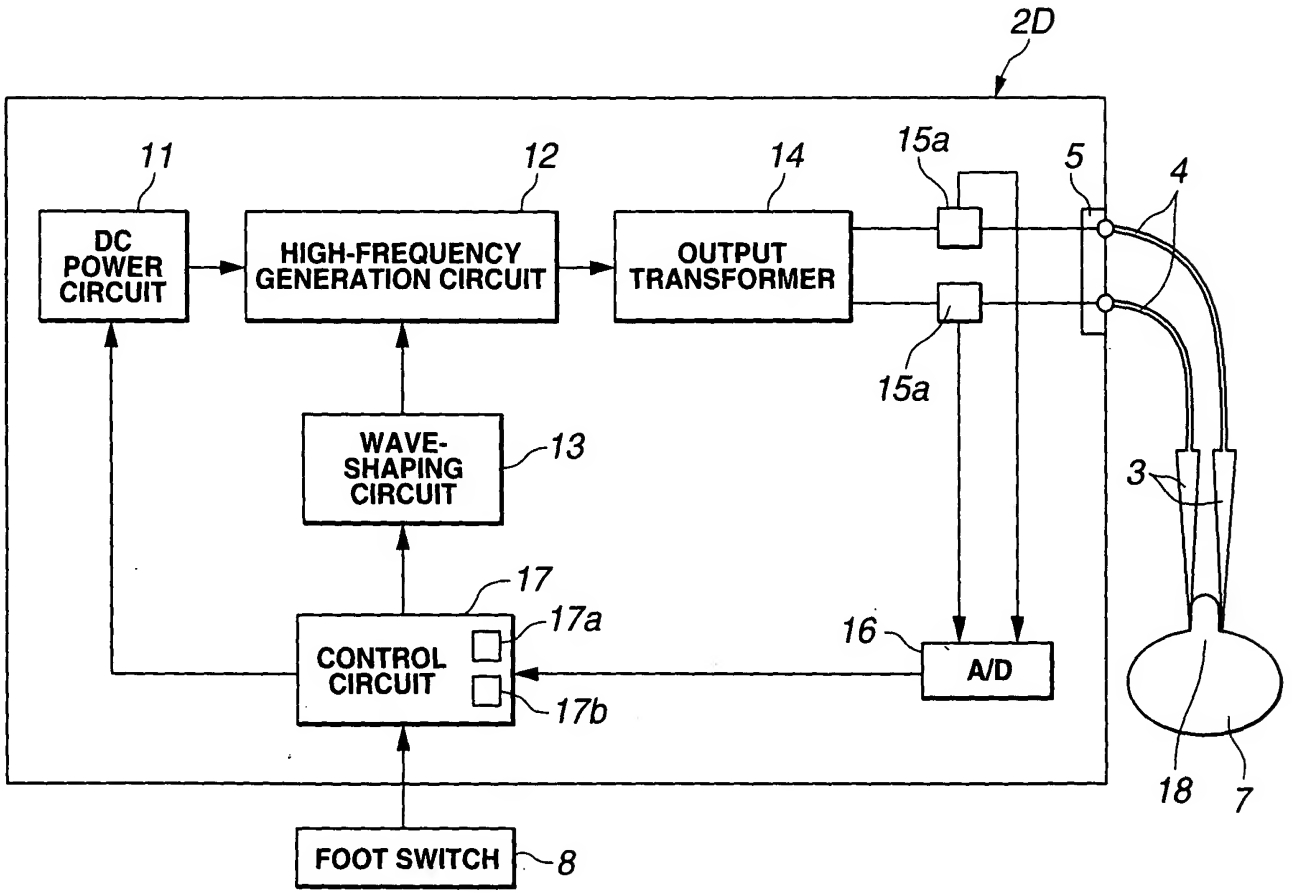

2D
11
12
14
15a
5
4
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
15a
WAVE-SHAPING CIRCUIT
13
3
17
17a
16
CONTROL CIRCUIT
A/D
17b
18
7
FOOT SWITCH
8

FIG.14A

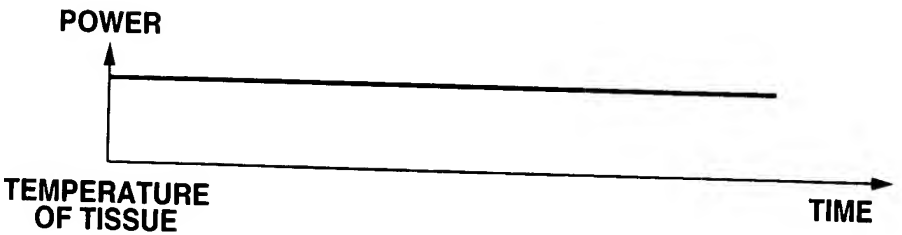


FIG.14B

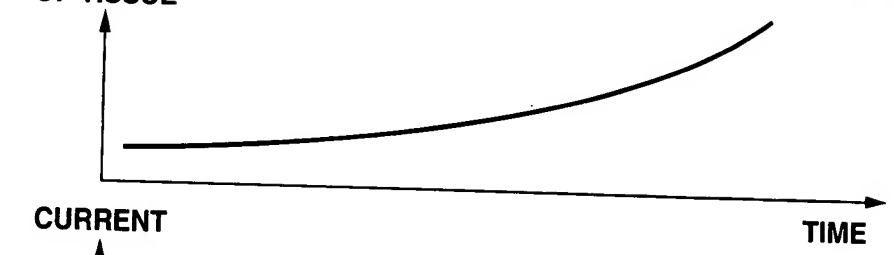


FIG.14C

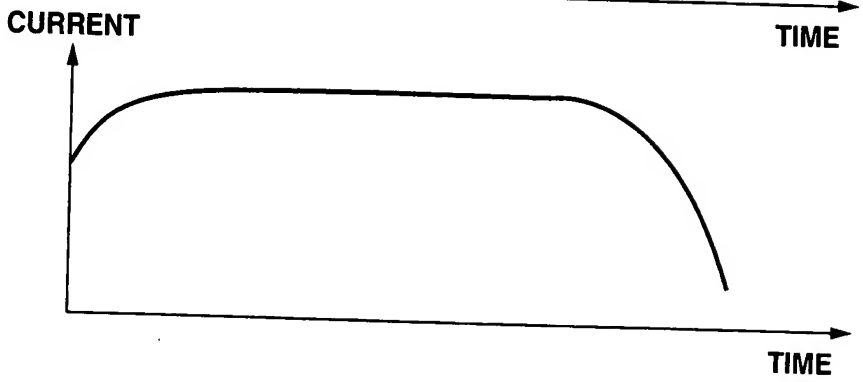
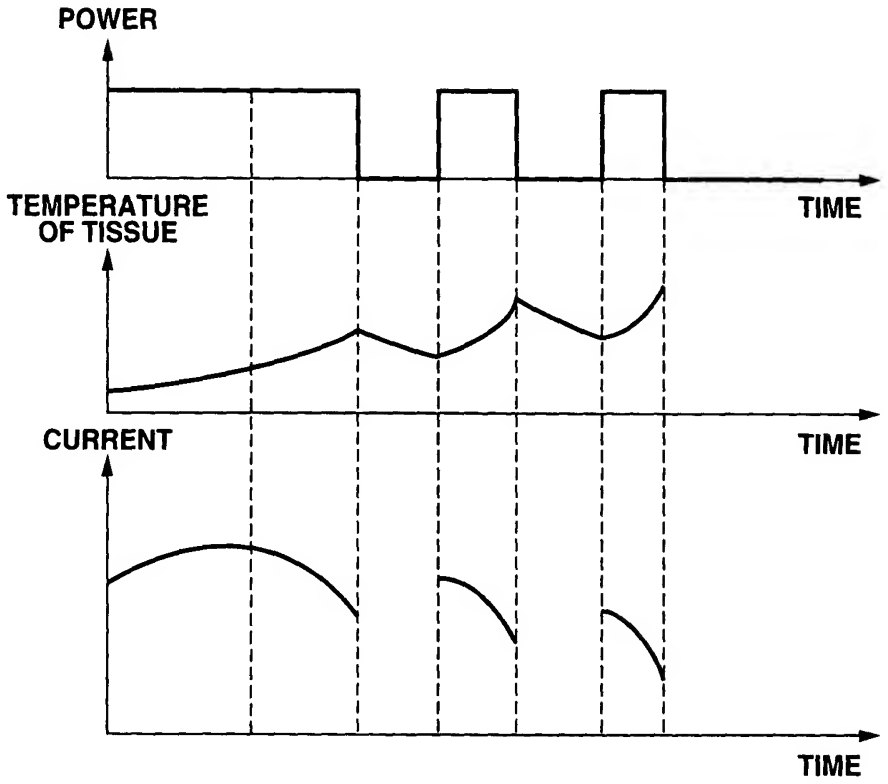


FIG.15A

FIG.15B

FIG.15C



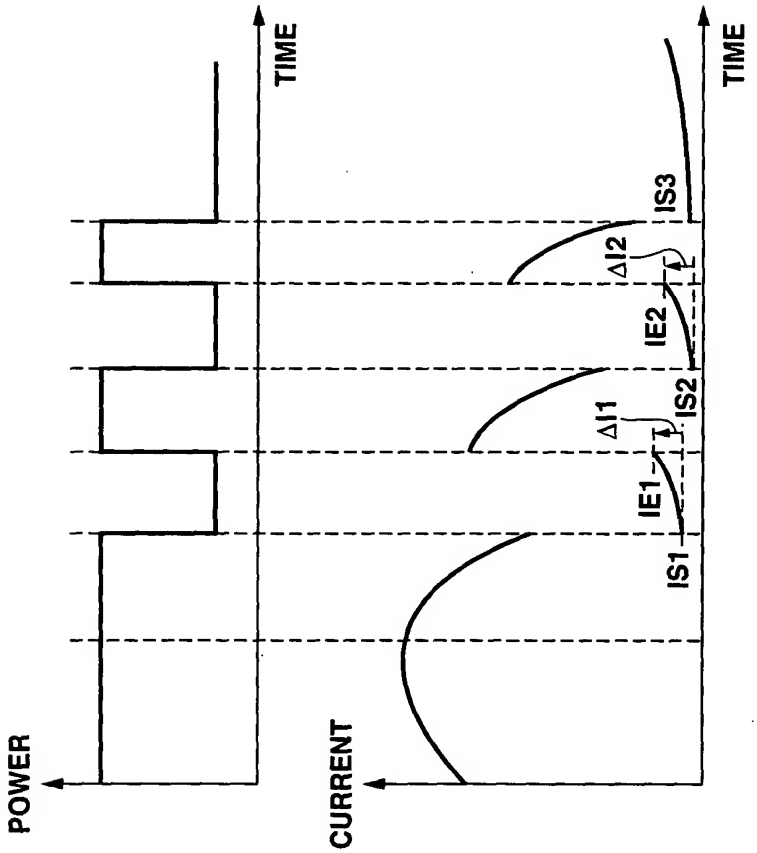


FIG.16A

FIG.16B

FIG.17A

FIG.17B

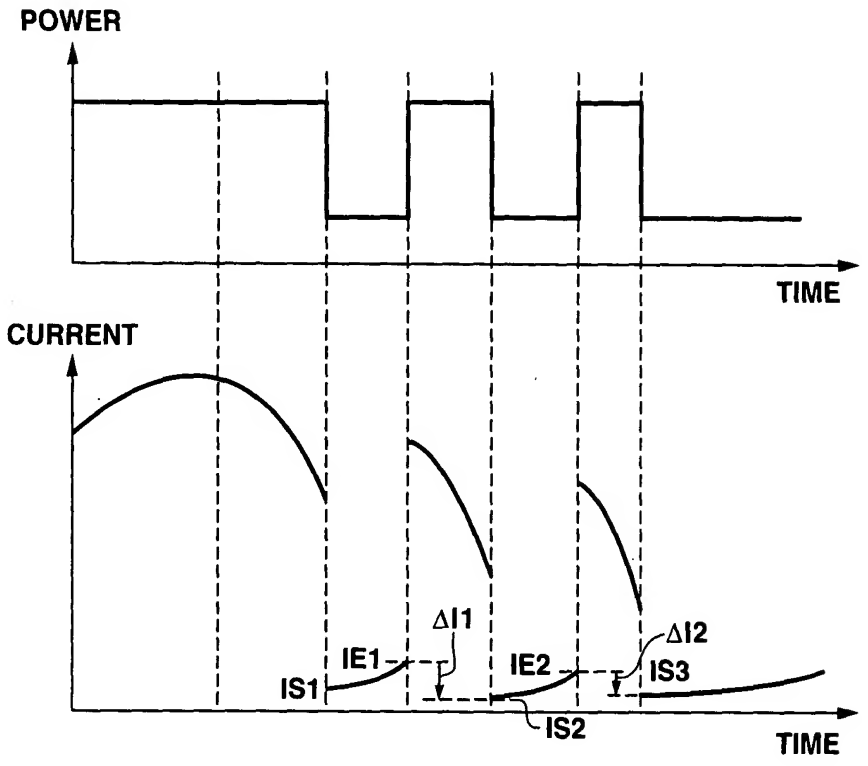


FIG.18A

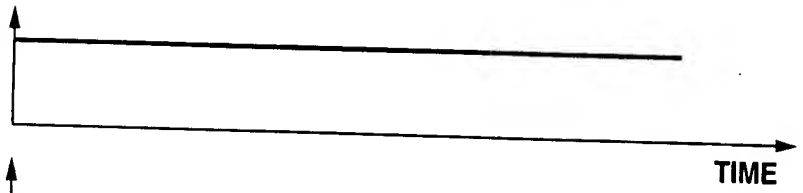


FIG.18B

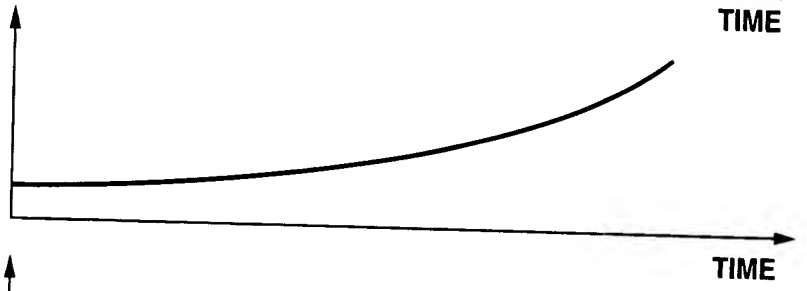


FIG.18C

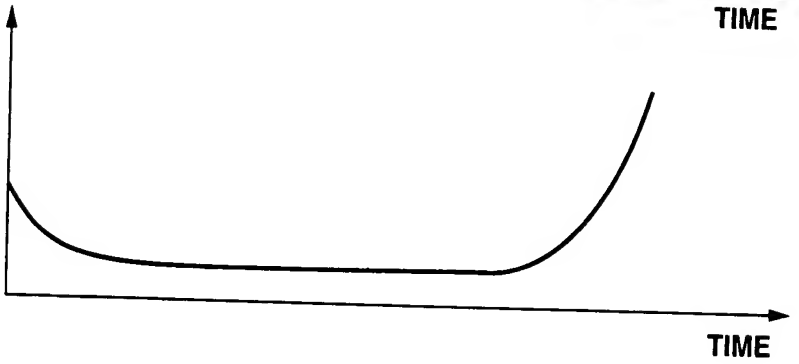


FIG.19

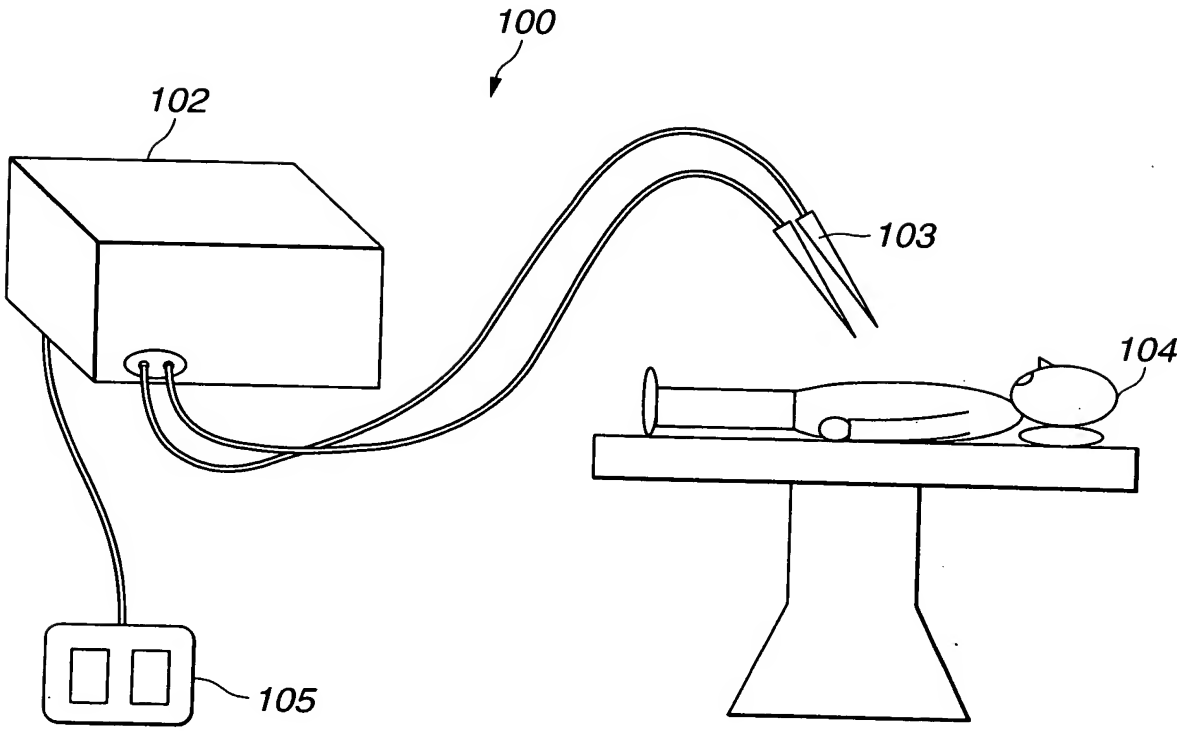


FIG.20

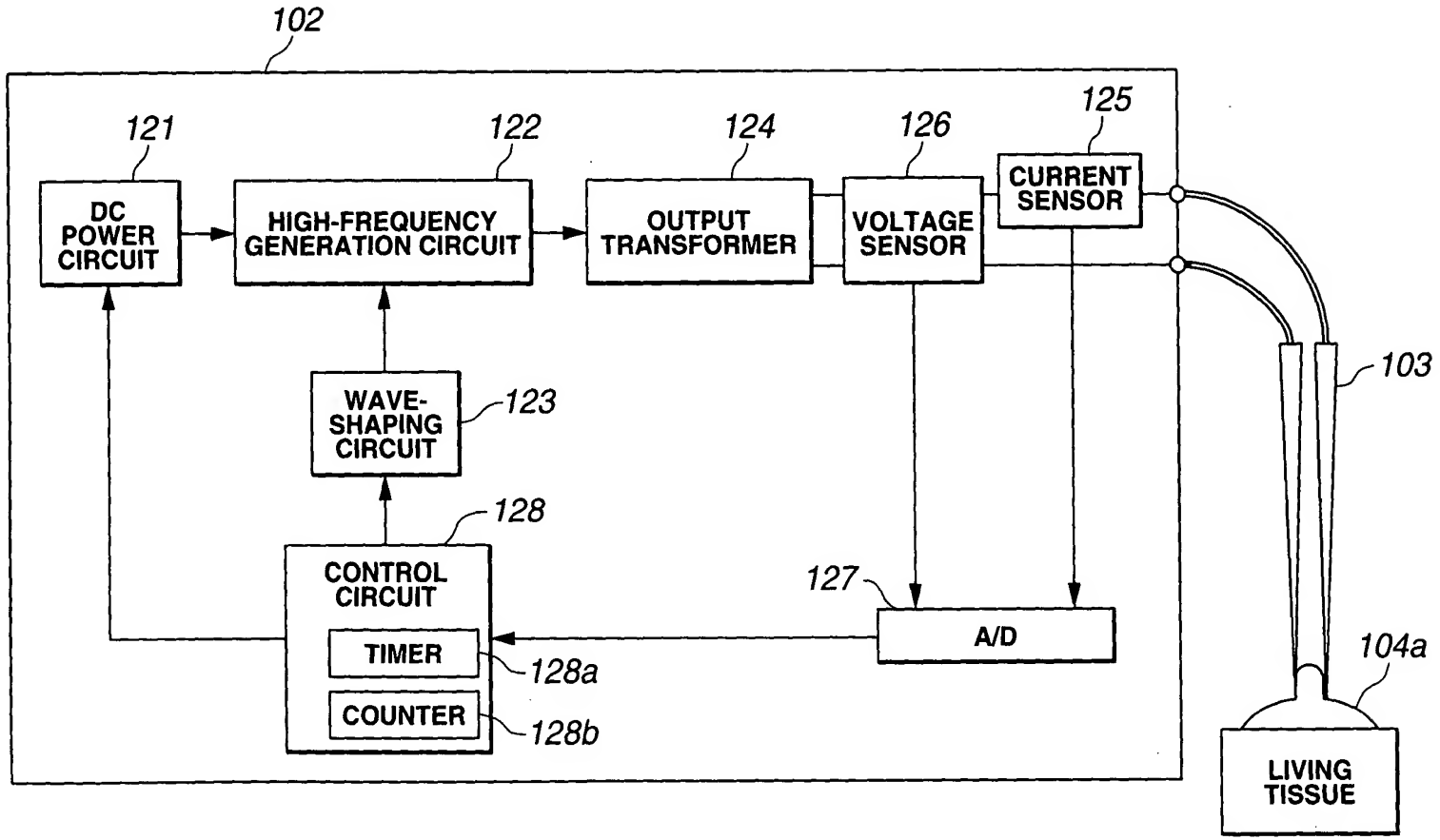

102
121
122
124
126
125
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
103
WAVE-SHAPING CIRCUIT
123
128
CONTROL CIRCUIT
TIMER
128a
COUNTER
128b
127
A/D
104a
LIVING TISSUE

FIG.21A

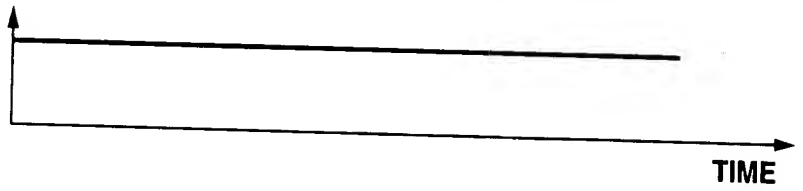


FIG.21B

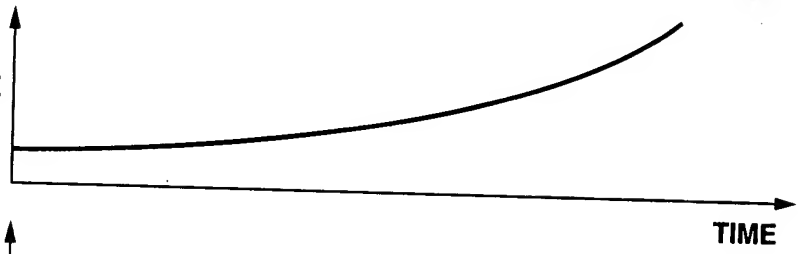


FIG.21C

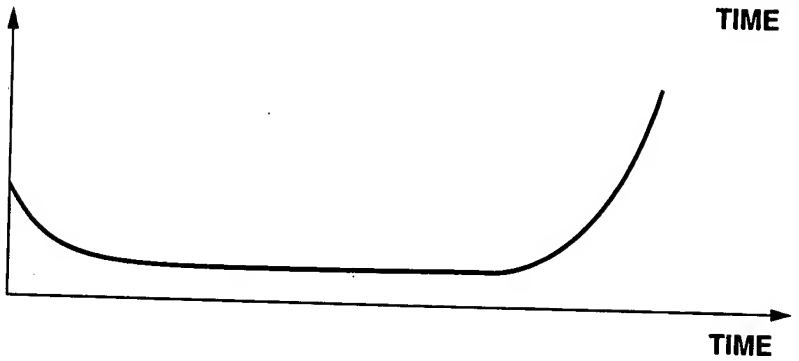


FIG.22A

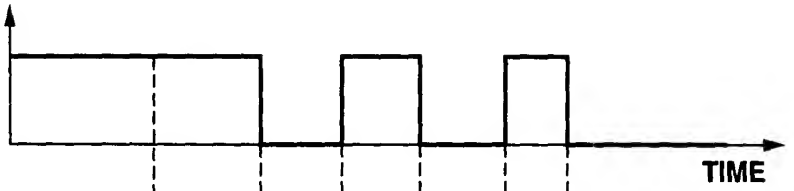


FIG.22B

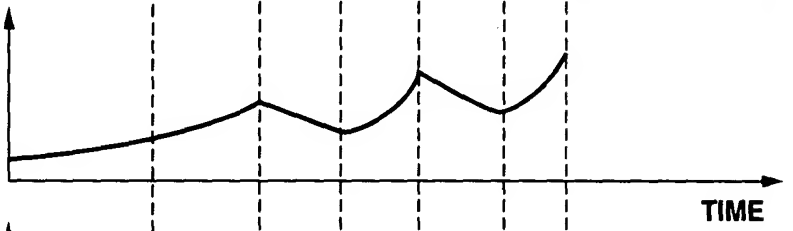


FIG.22C

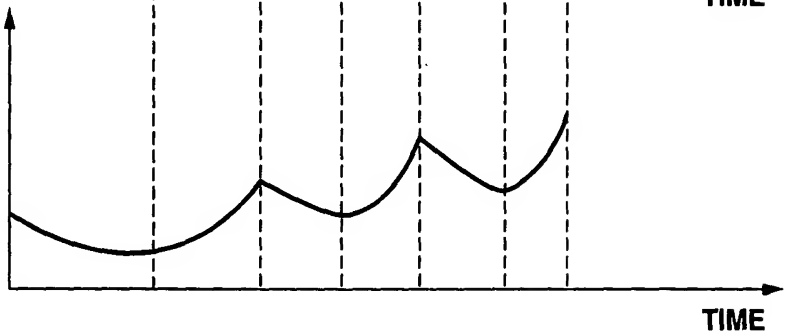


FIG.23

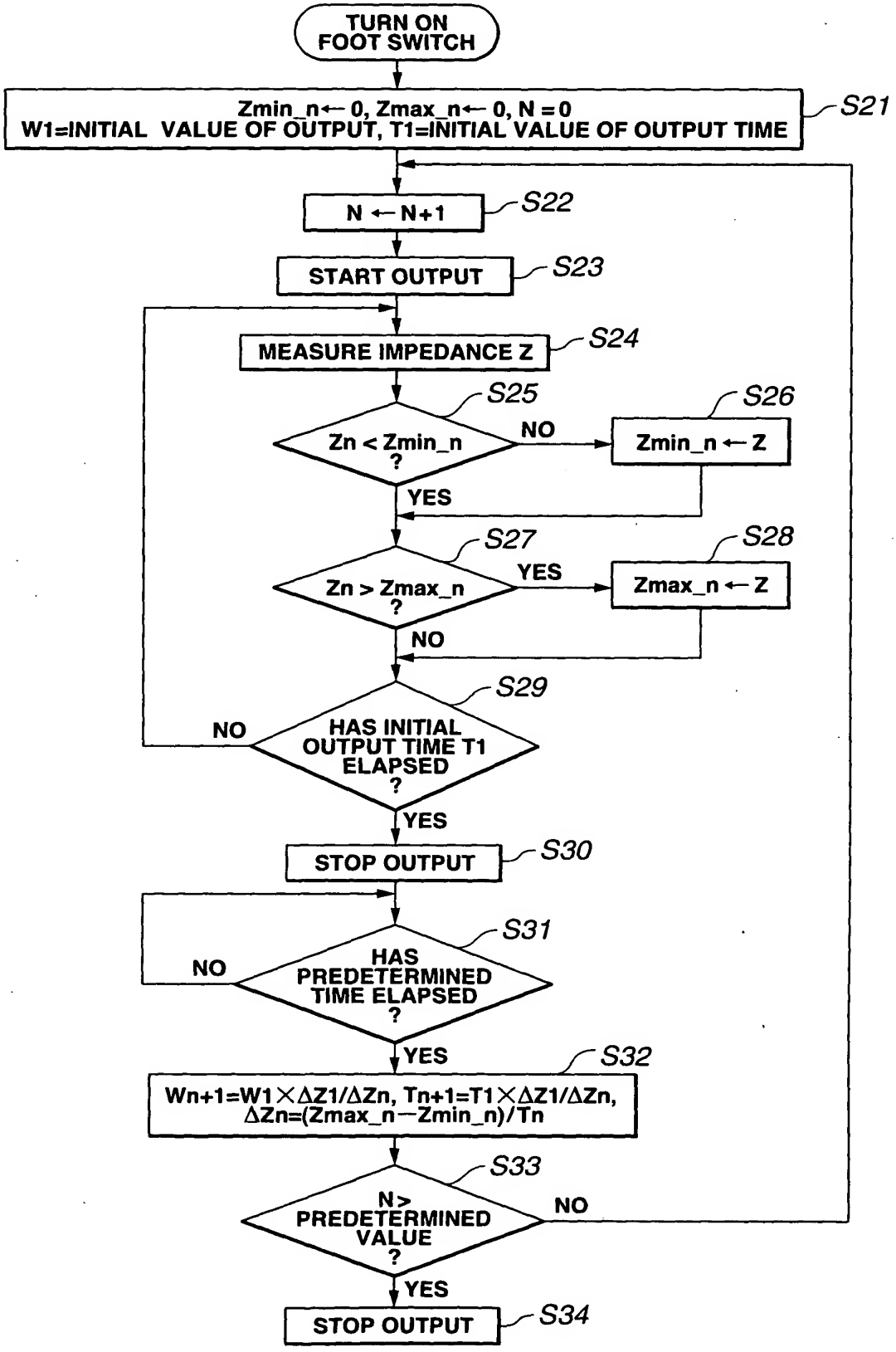

TURN ON FOOT SWITCH
Zmin_n← 0, Zmax_n← 0, N = 0
W1=INITIAL VALUE OF OUTPUT, T1=INITIAL VALUE OF OUTPUT TIME
S21
N ← N+1
S22
START OUTPUT
S23
MEASURE IMPEDANCE Z
S24
S25
Zn < Zmin_n ?
NO
S26
Zmin_n ← Z
YES
S27
Zn > Zmax_n ?
YES
S28
Zmax_n ← Z
NO
S29
NO
HAS INITIAL OUTPUT TIME T1 ELAPSED ?
YES
STOP OUTPUT
S30
S31
NO
HAS PREDETERMINED TIME ELAPSED ?
YES
S32
Wn+1=W1×ΔZ1/ΔZn, Tn+1=T1×ΔZ1/ΔZn,
ΔZn=(Zmax_n−Zmin_n)/Tn
S33
N> PREDETERMINED VALUE ?
NO
YES
STOP OUTPUT
S34

FIG.24A

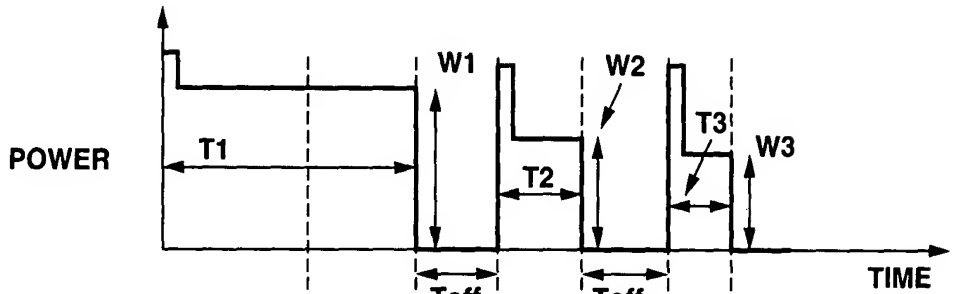


FIG.24B

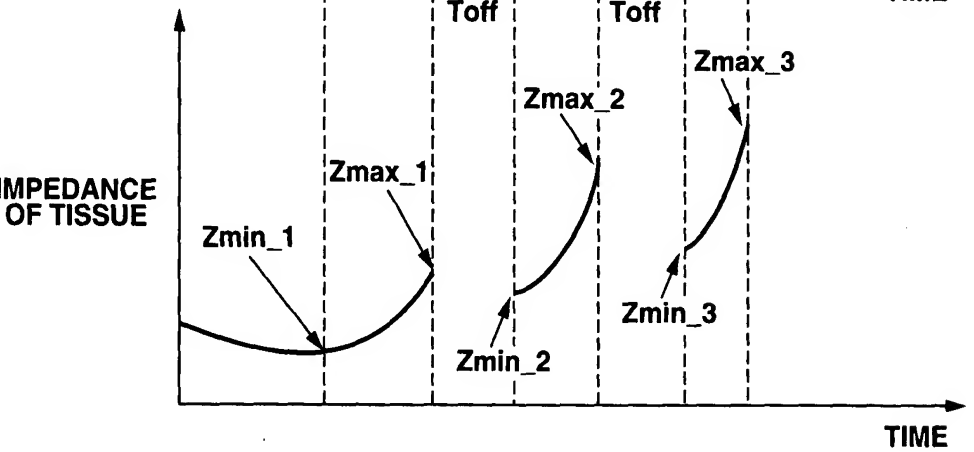


FIG.25

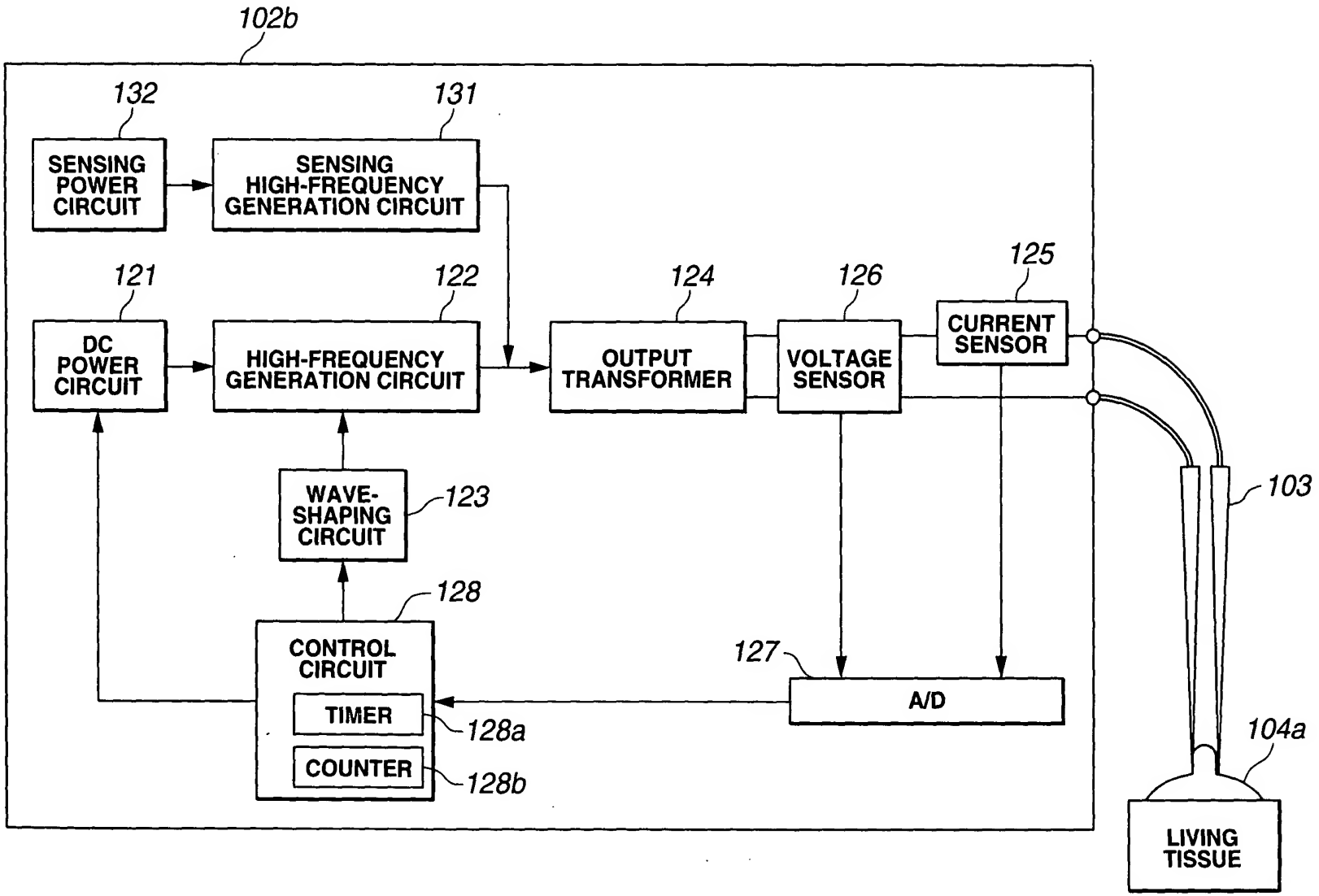

102b
132
131
SENSING POWER CIRCUIT
SENSING HIGH-FREQUENCY GENERATION CIRCUIT
121
122
124
126
125
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
WAVE-SHAPING CIRCUIT
123
103
128
CONTROL CIRCUIT
127
A/D
TIMER
128a
COUNTER
128b
104a
LIVING TISSUE

FIG.26A

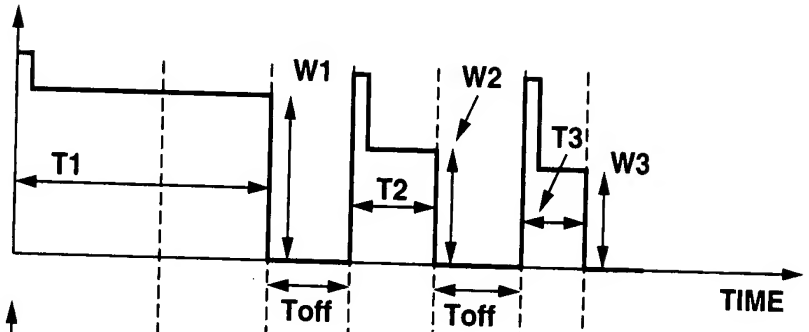


FIG.26B

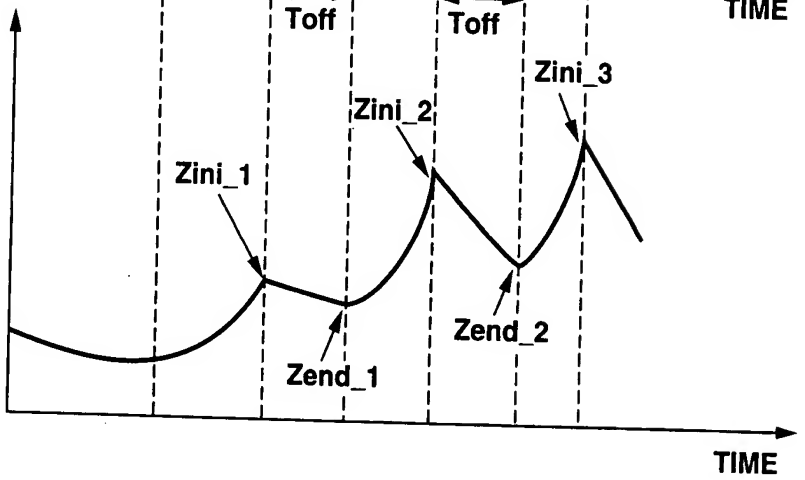


FIG.27

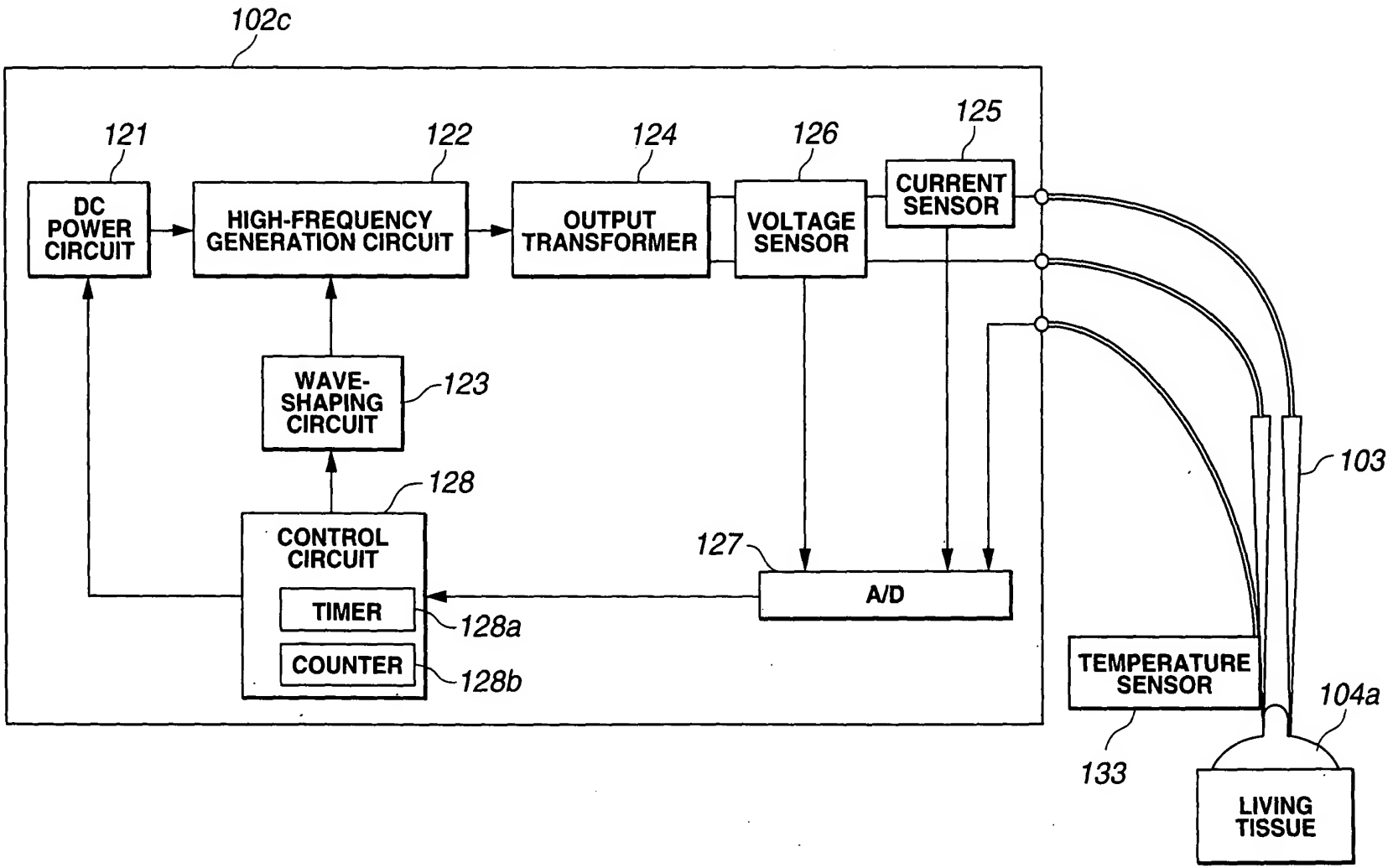

102c
121
122
124
126
125
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
WAVE-SHAPING CIRCUIT
123
128
CONTROL CIRCUIT
TIMER
128a
COUNTER
128b
127
A/D
103
TEMPERATURE SENSOR
104a
133
LIVING TISSUE

FIG.28A

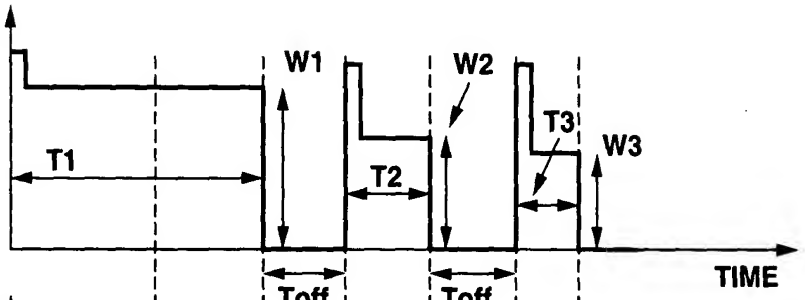


FIG.28B

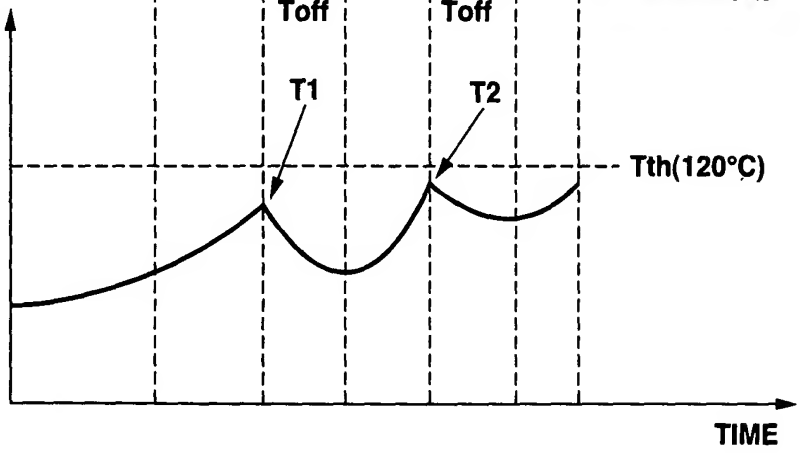


FIG.29

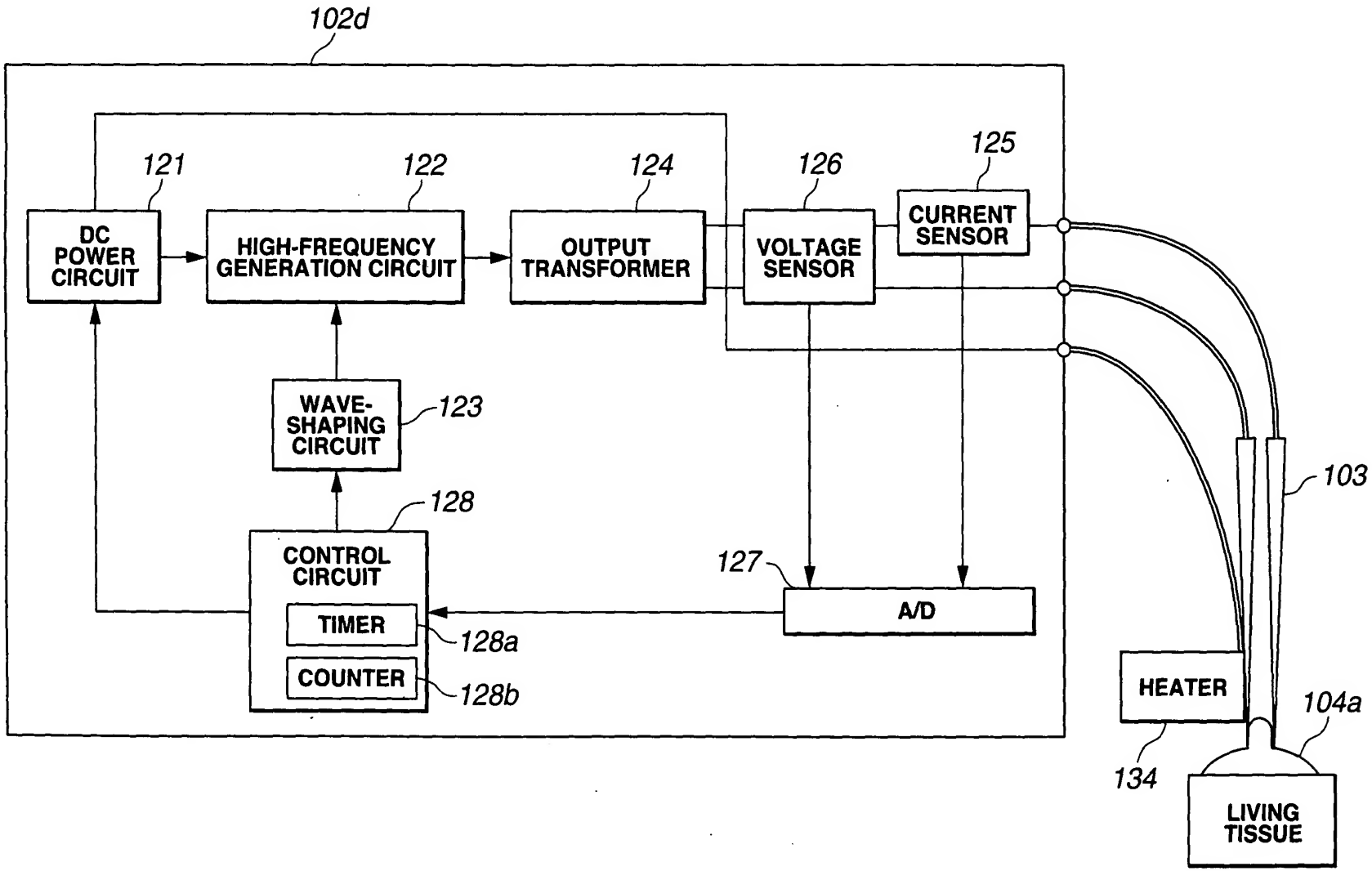

102d
121
122
124
126
125
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
WAVE-SHAPING CIRCUIT
123
128
CONTROL CIRCUIT
TIMER
128a
COUNTER
128b
127
A/D
103
HEATER
104a
134
LIVING TISSUE

FIG.30

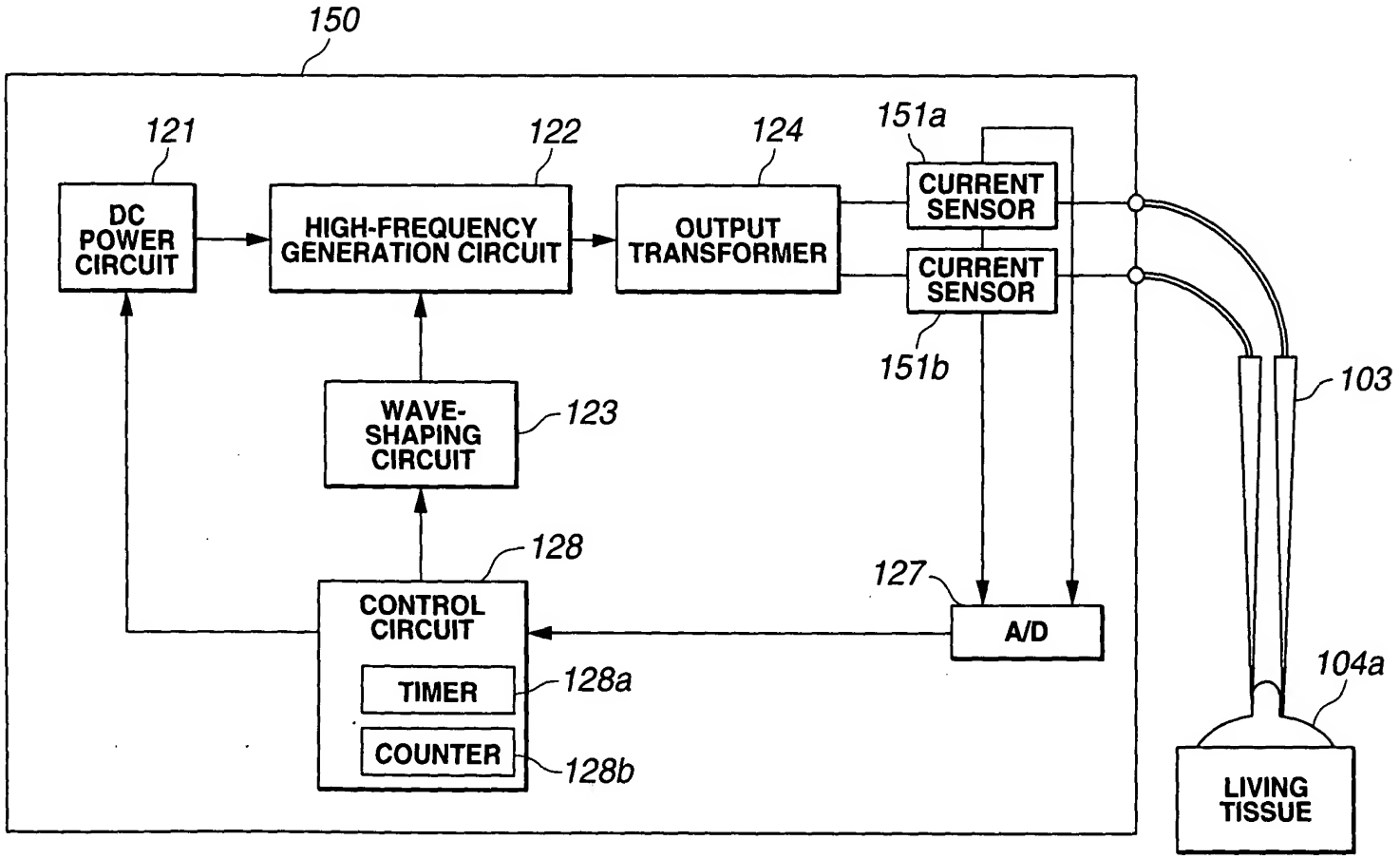

150
121
DC POWER CIRCUIT
122
HIGH-FREQUENCY GENERATION CIRCUIT
124
OUTPUT TRANSFORMER
151a
CURRENT SENSOR
CURRENT SENSOR
151b
103
WAVE-SHAPING CIRCUIT
123
128
CONTROL CIRCUIT
TIMER
128a
COUNTER
128b
127
A/D
104a
LIVING TISSUE

FIG.31A

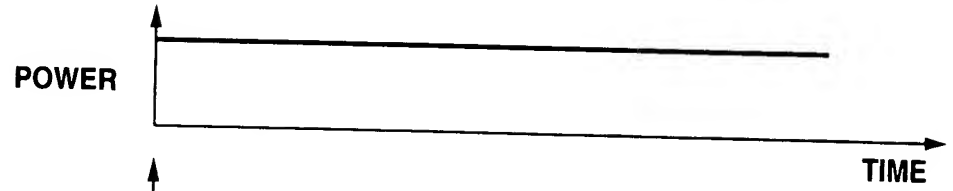


FIG.31B

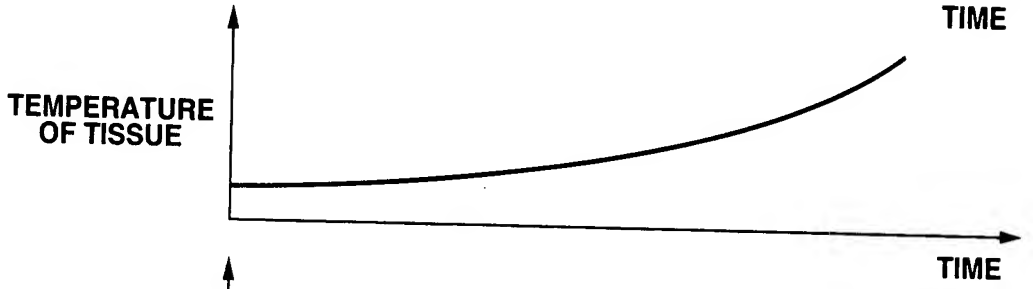


FIG.31C

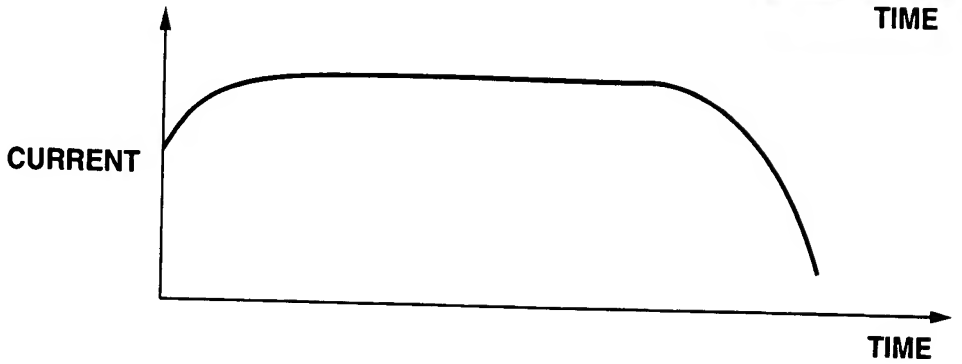


FIG.32A

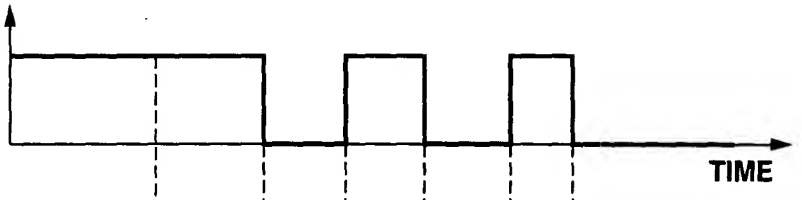


FIG.32B

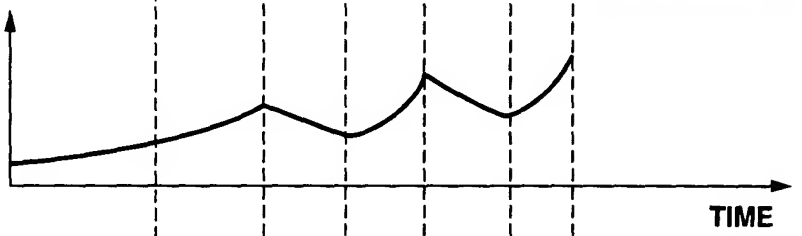


FIG.32C

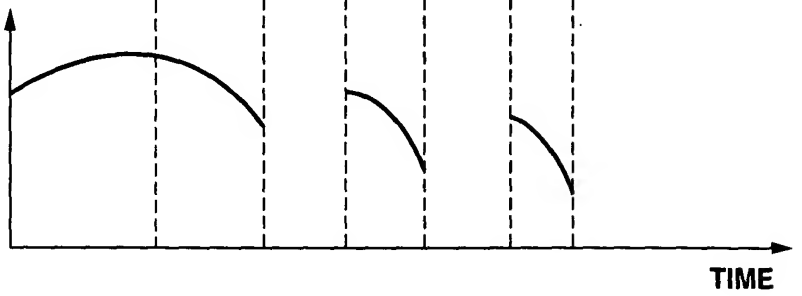


FIG.33A

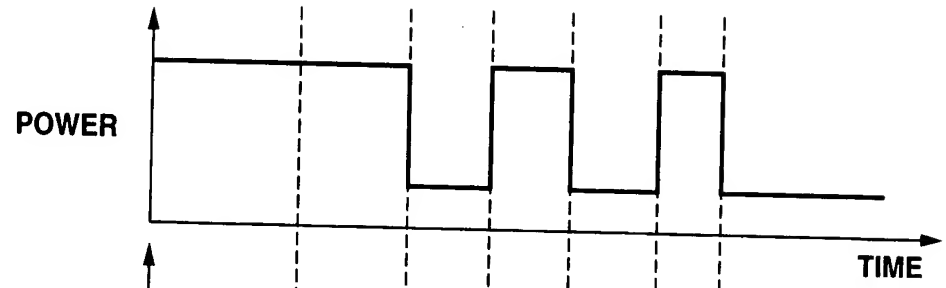


FIG.33B

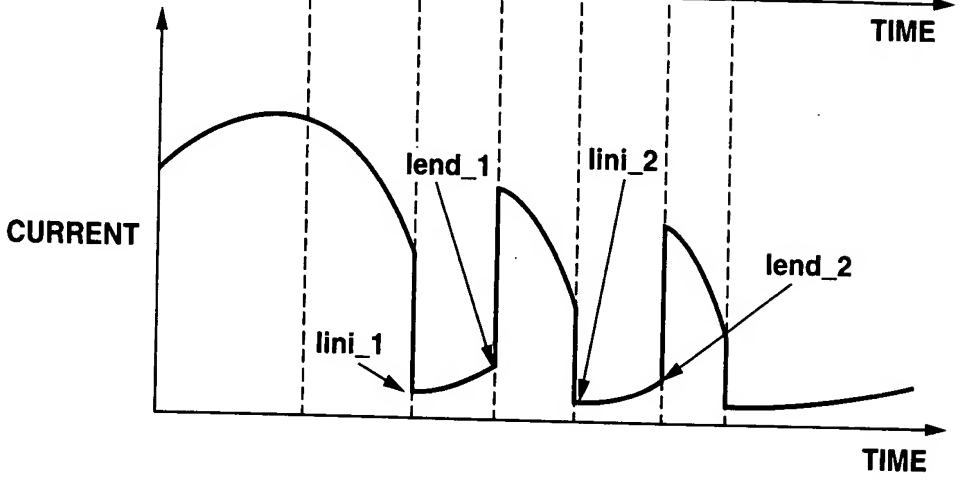


FIG.34

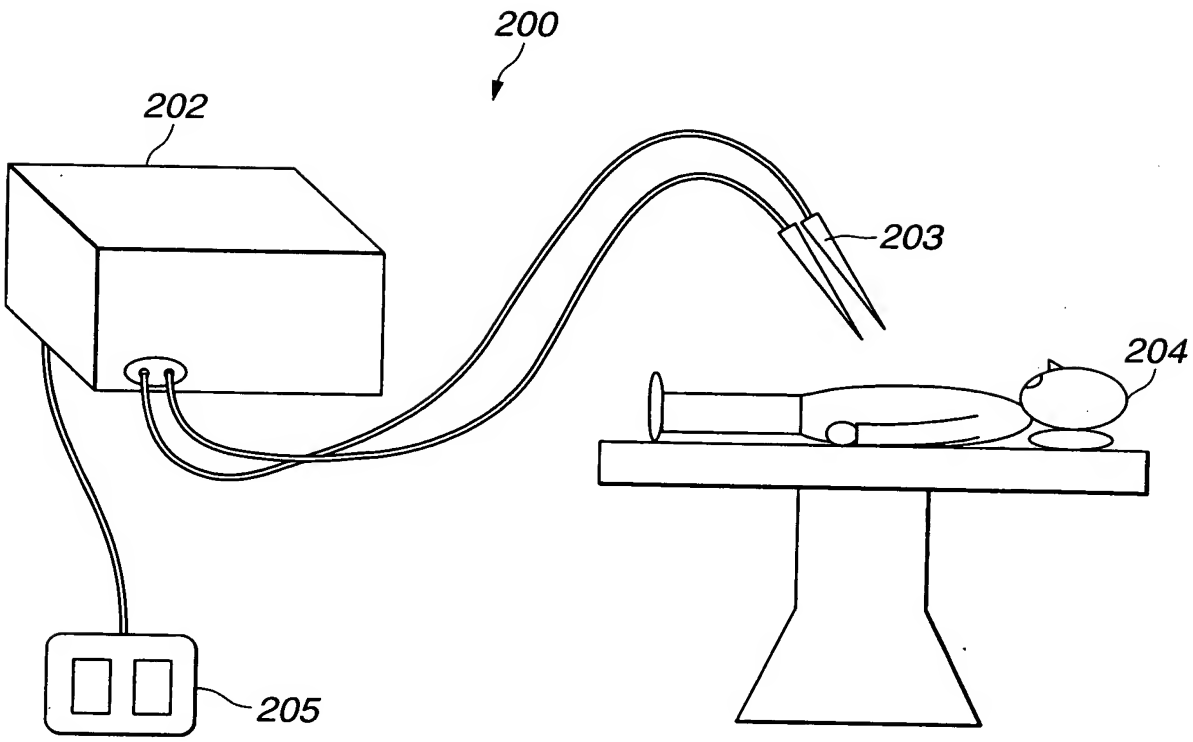


FIG.35

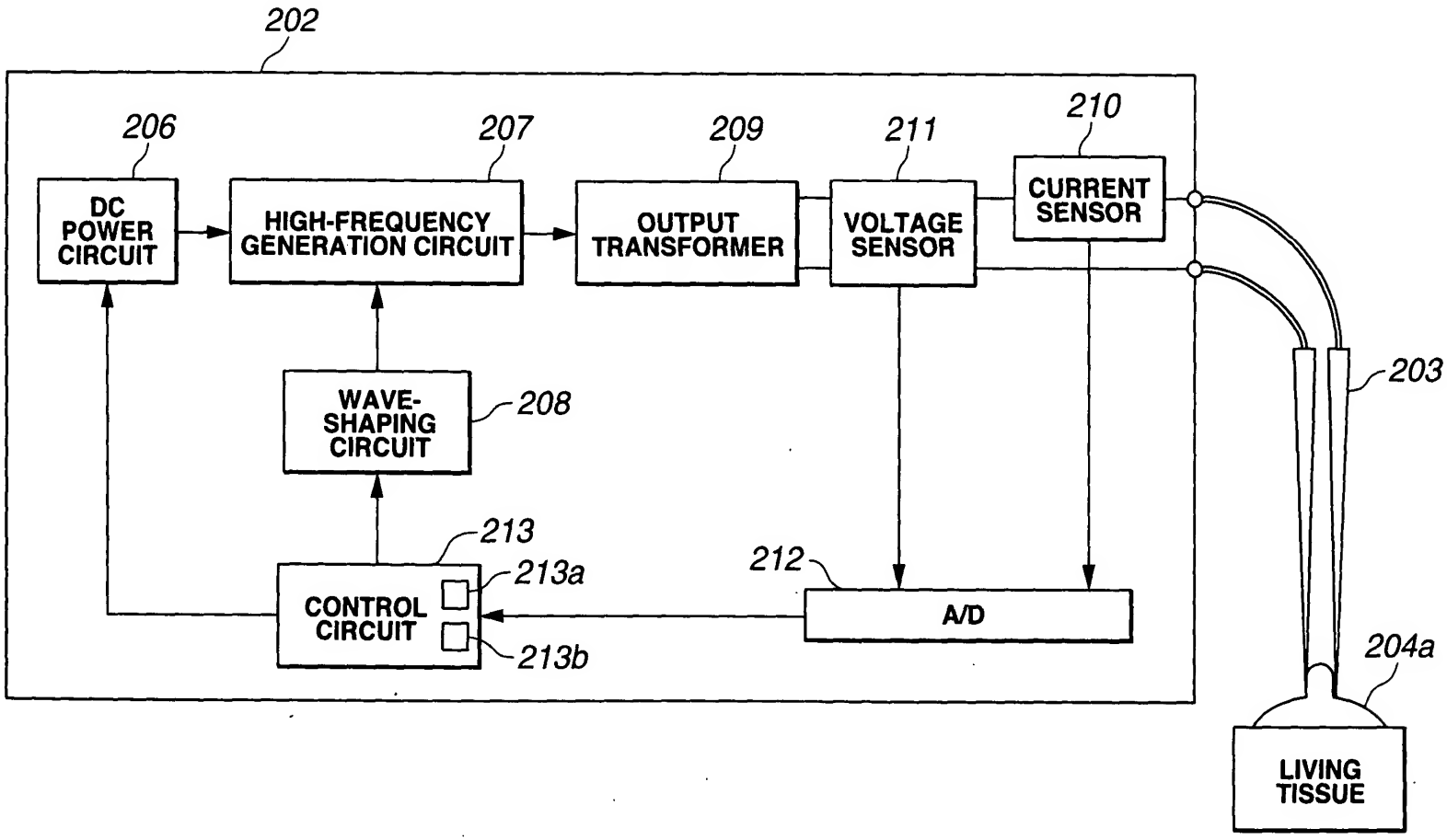

202
206
207
209
211
210
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
203
WAVE-SHAPING CIRCUIT
208
213
213a
212
CONTROL CIRCUIT
A/D
213b
204a
LIVING TISSUE

FIG.36A

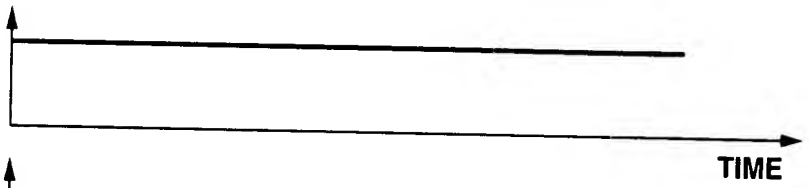


FIG.36B

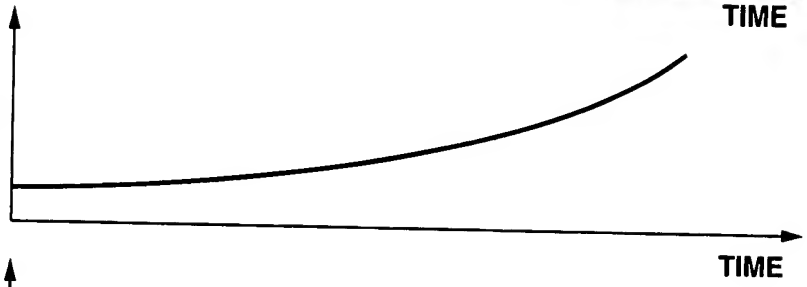


FIG.36C

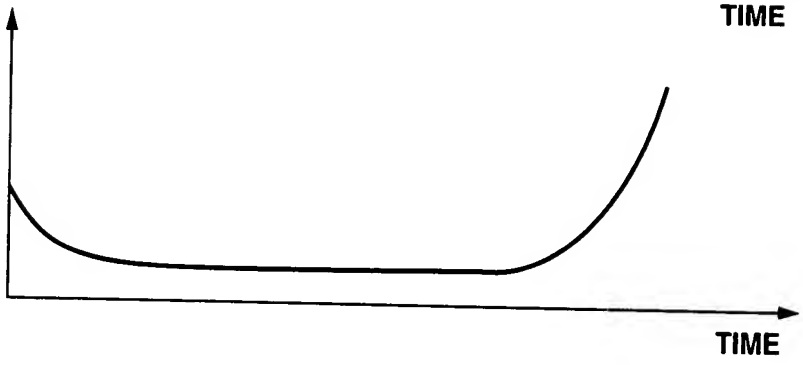


FIG.37A

FIG.37B

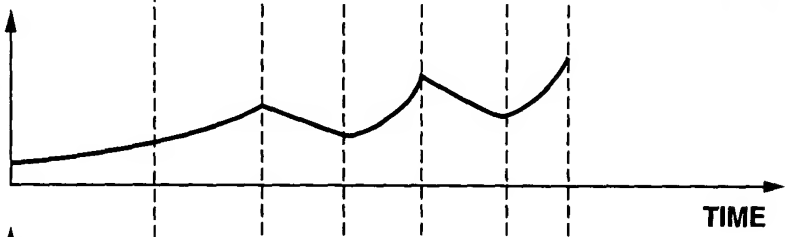


FIG.37C

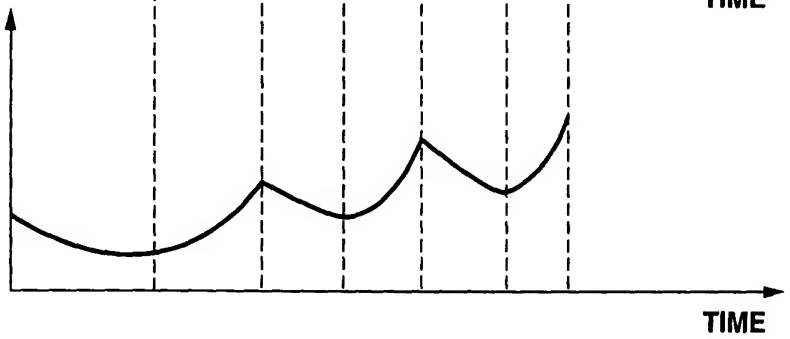


FIG.38

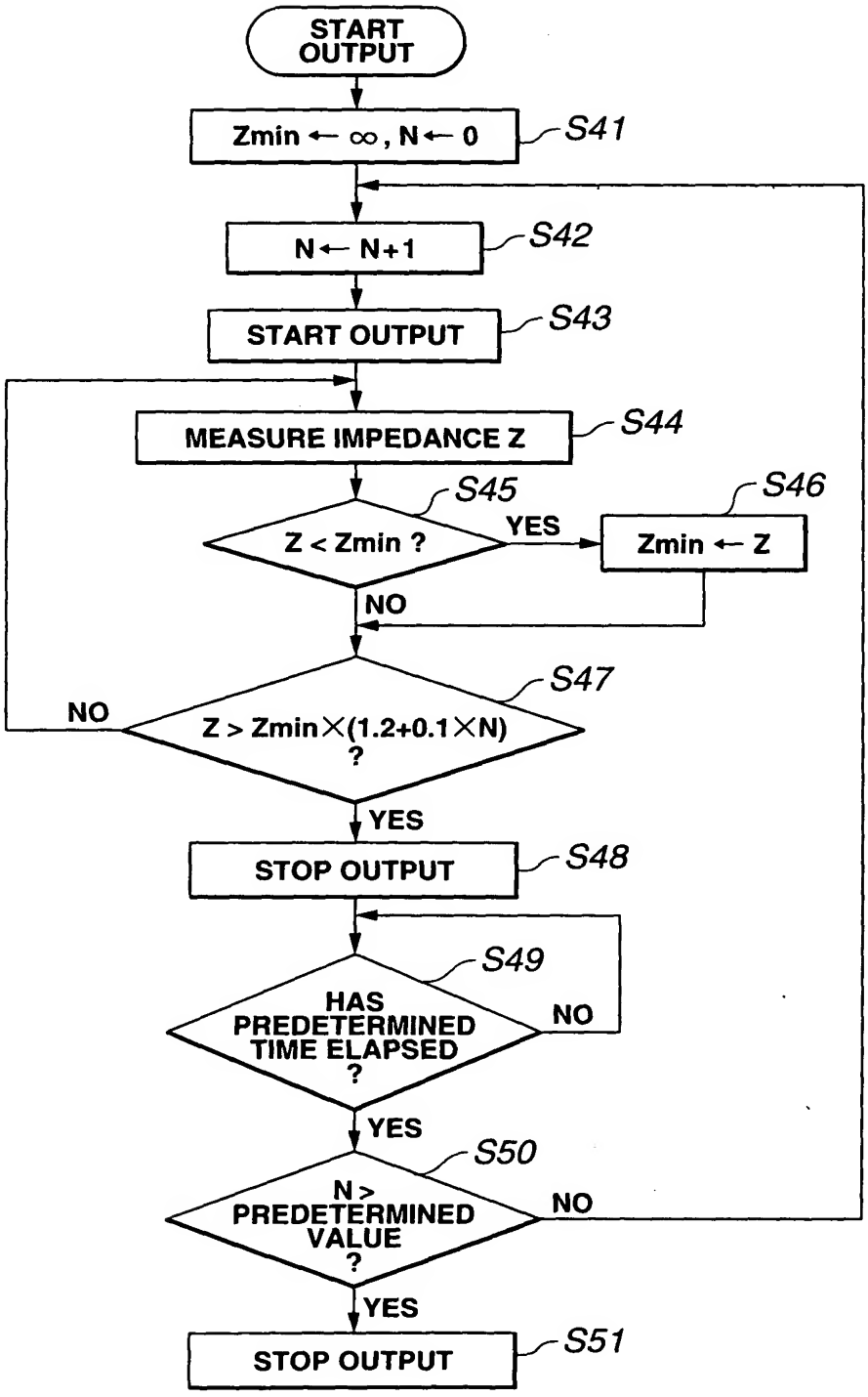

START OUTPUT
Zmin ← ∞, N ← 0
S41
N ← N+1
S42
START OUTPUT
S43
MEASURE IMPEDANCE Z
S44
S45
Z < Zmin ?
YES
S46
Zmin ← Z
NO
S47
NO
Z > Zmin×(1.2+0.1×N) ?
YES
STOP OUTPUT
S48
S49
HAS PREDETERMINED TIME ELAPSED ?
NO
YES
S50
N > PREDETERMINED VALUE ?
NO
YES
STOP OUTPUT
S51

FIG.39A

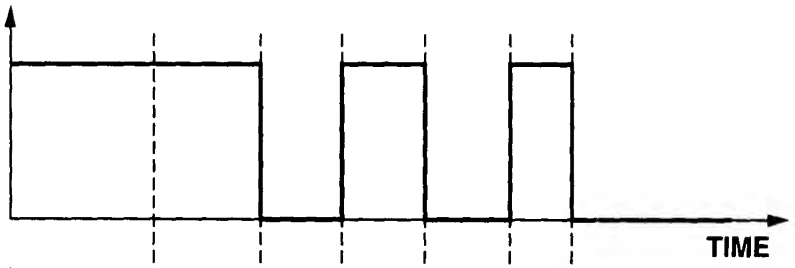


FIG.39B

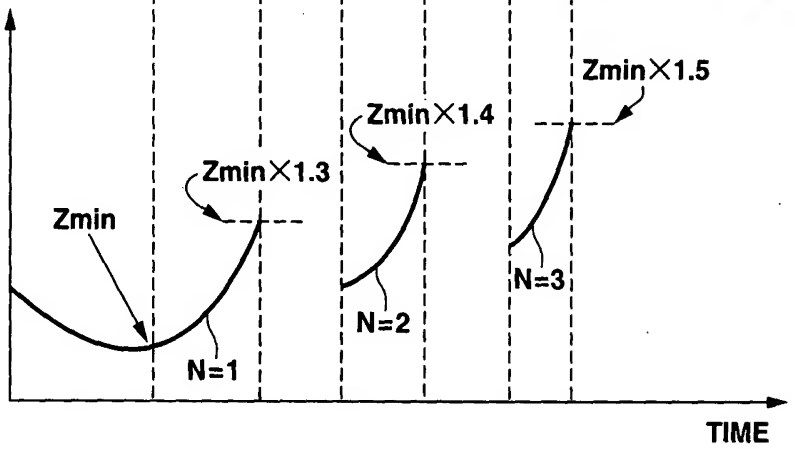


FIG.40A

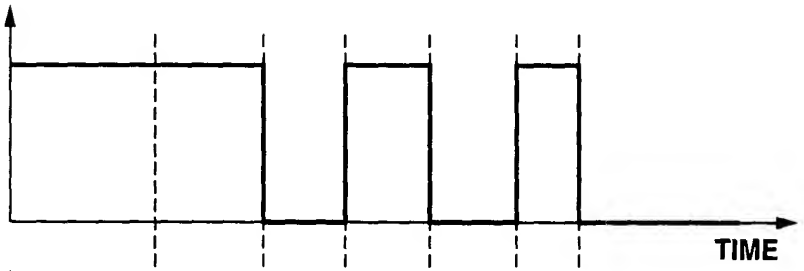


FIG.40B

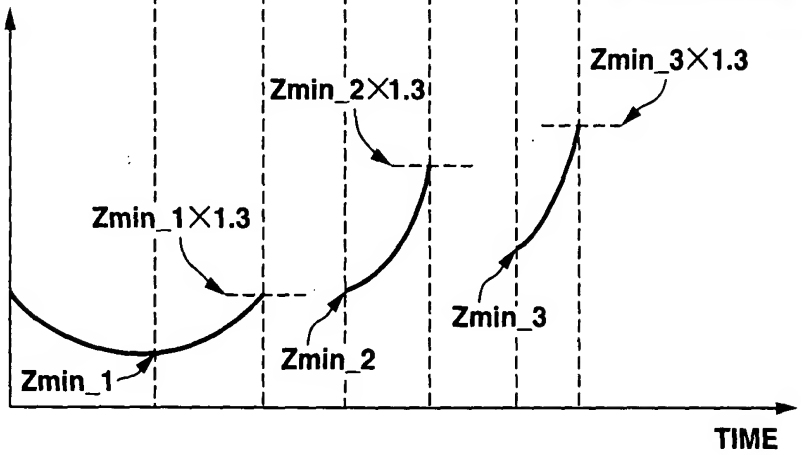


FIG.41A

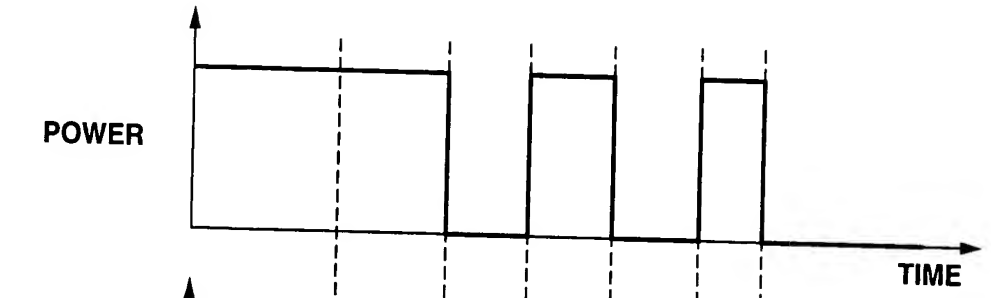


FIG.41B

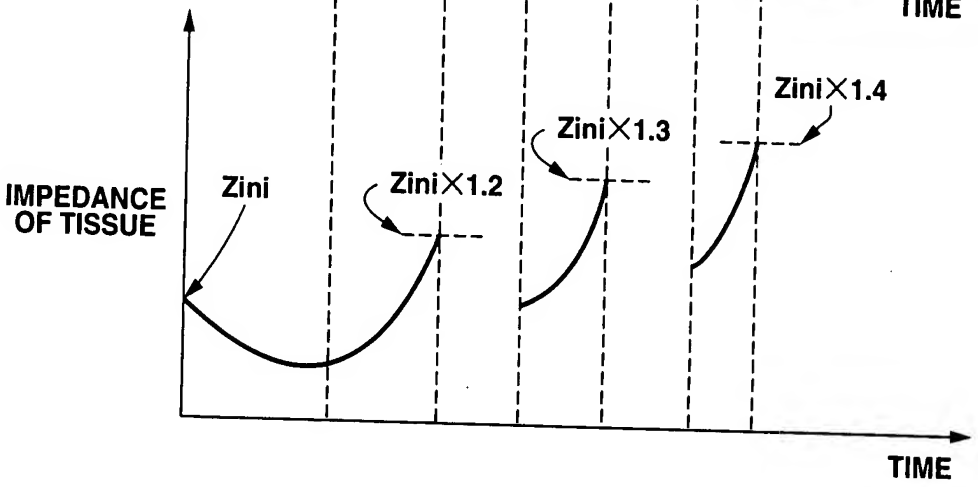


FIG.42A

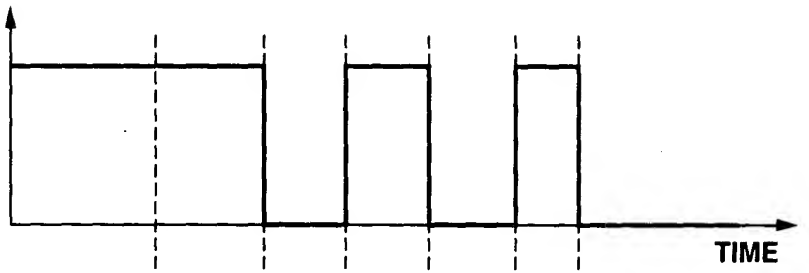


FIG.42B

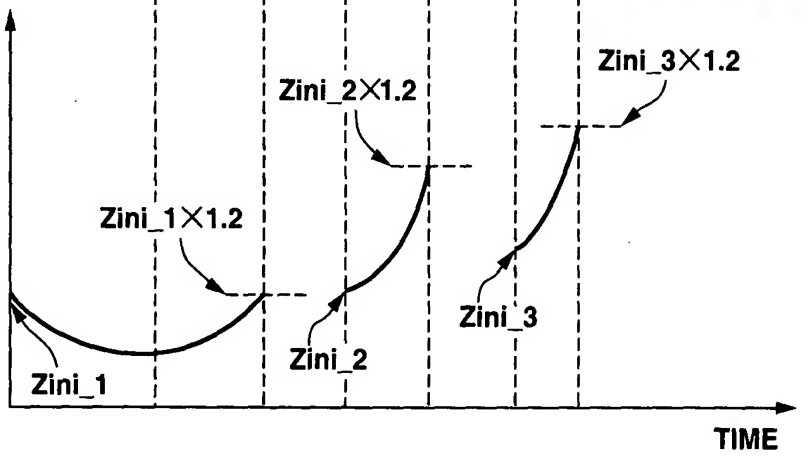


FIG.43

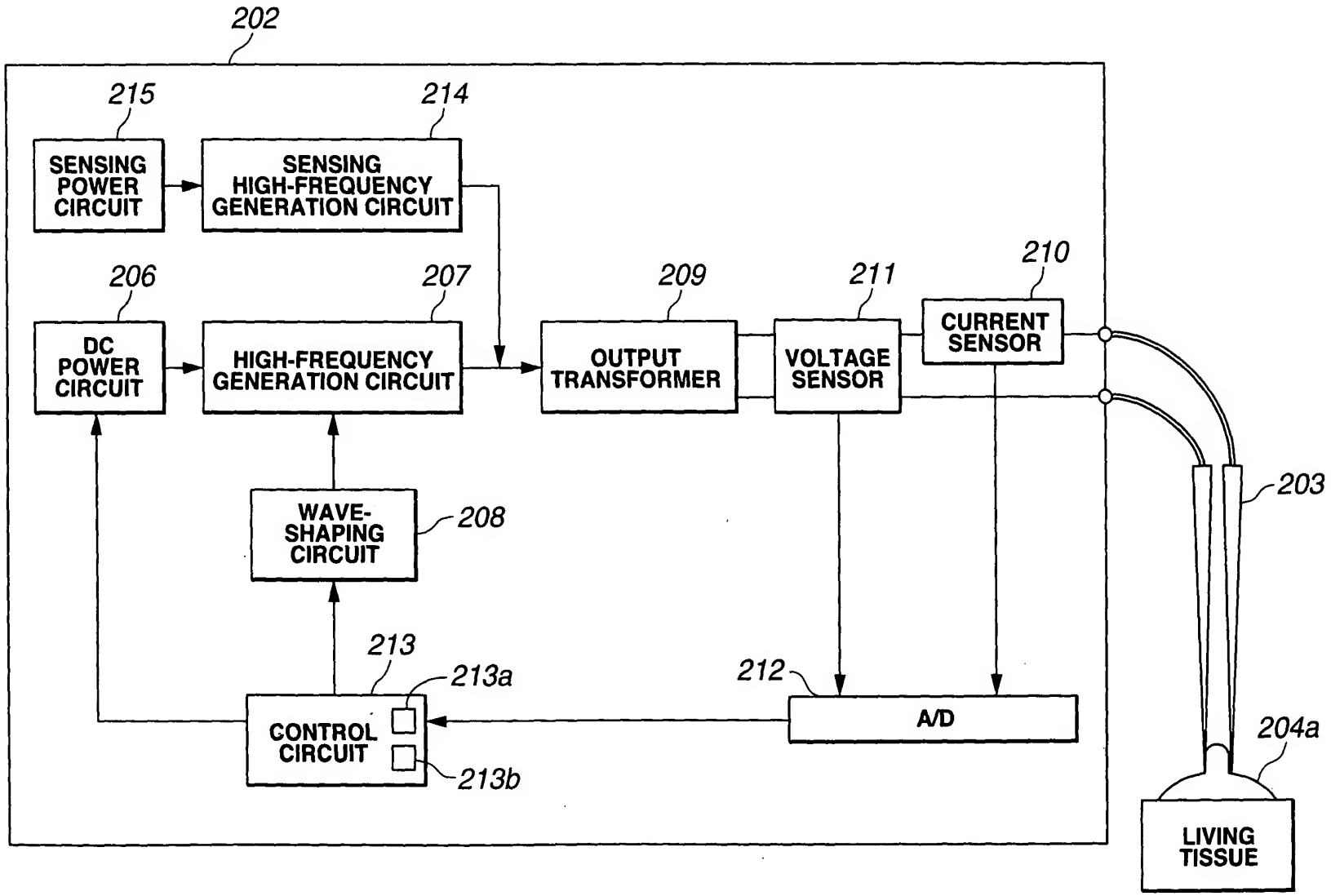

202
215
214
SENSING POWER CIRCUIT
SENSING HIGH-FREQUENCY GENERATION CIRCUIT
206
207
209
211
210
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
203
WAVE-SHAPING CIRCUIT
208
213
213a
212
CONTROL CIRCUIT
A/D
204a
213b
LIVING TISSUE

FIG.44

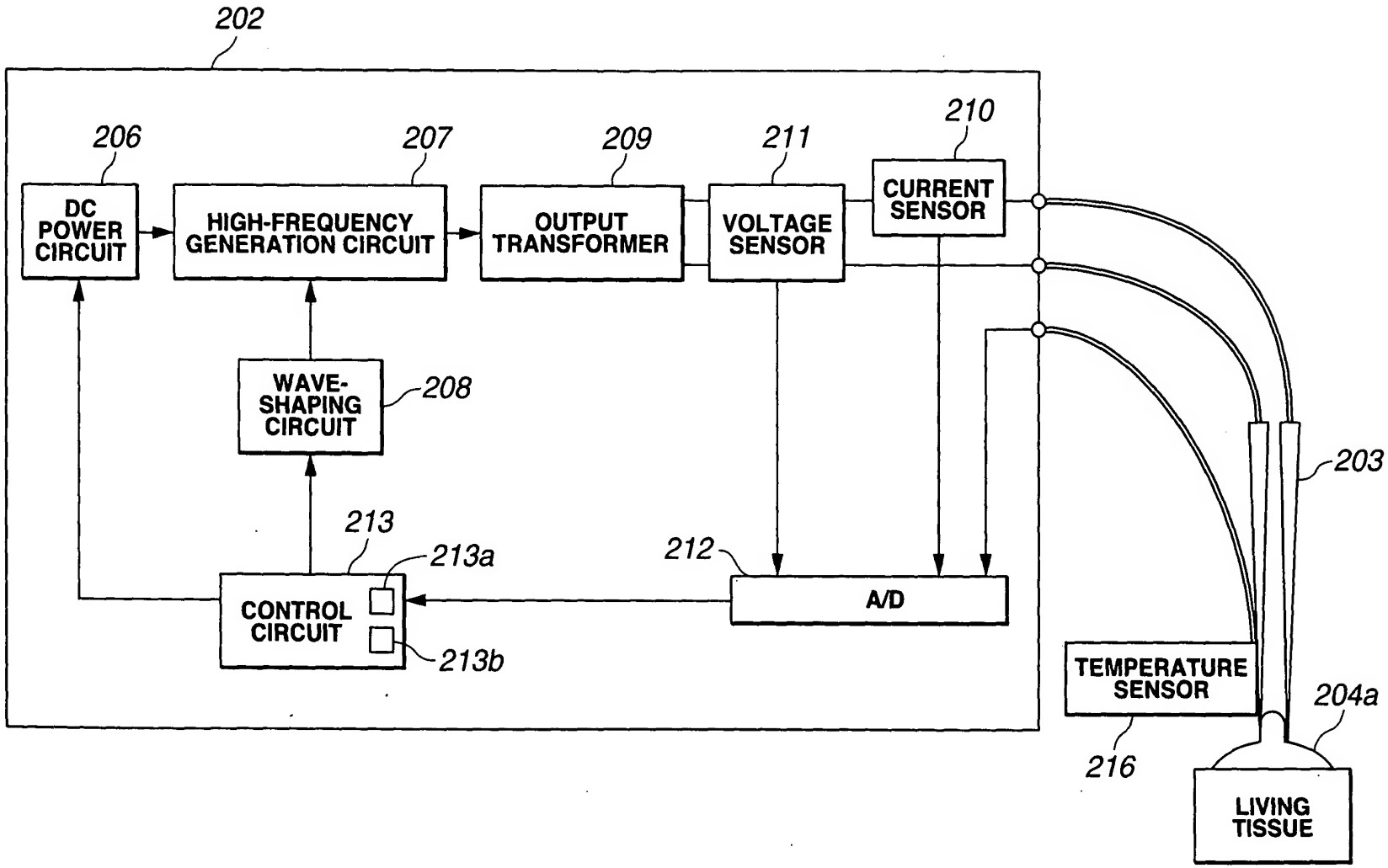

202
206
207
209
211
210
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
VOLTAGE SENSOR
CURRENT SENSOR
WAVE-SHAPING CIRCUIT
208
213
213a
212
CONTROL CIRCUIT
213b
A/D
203
TEMPERATURE SENSOR
204a
216
LIVING TISSUE

FIG.45A

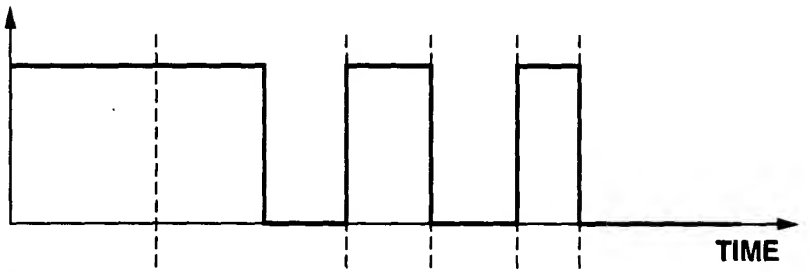


FIG.45B

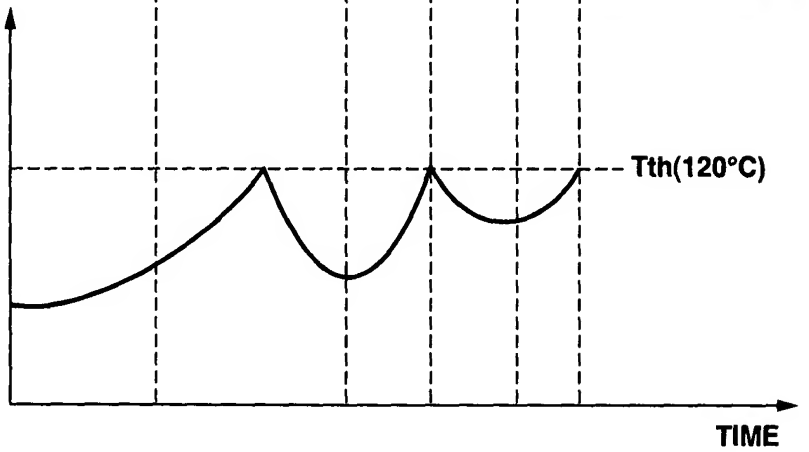


FIG.46

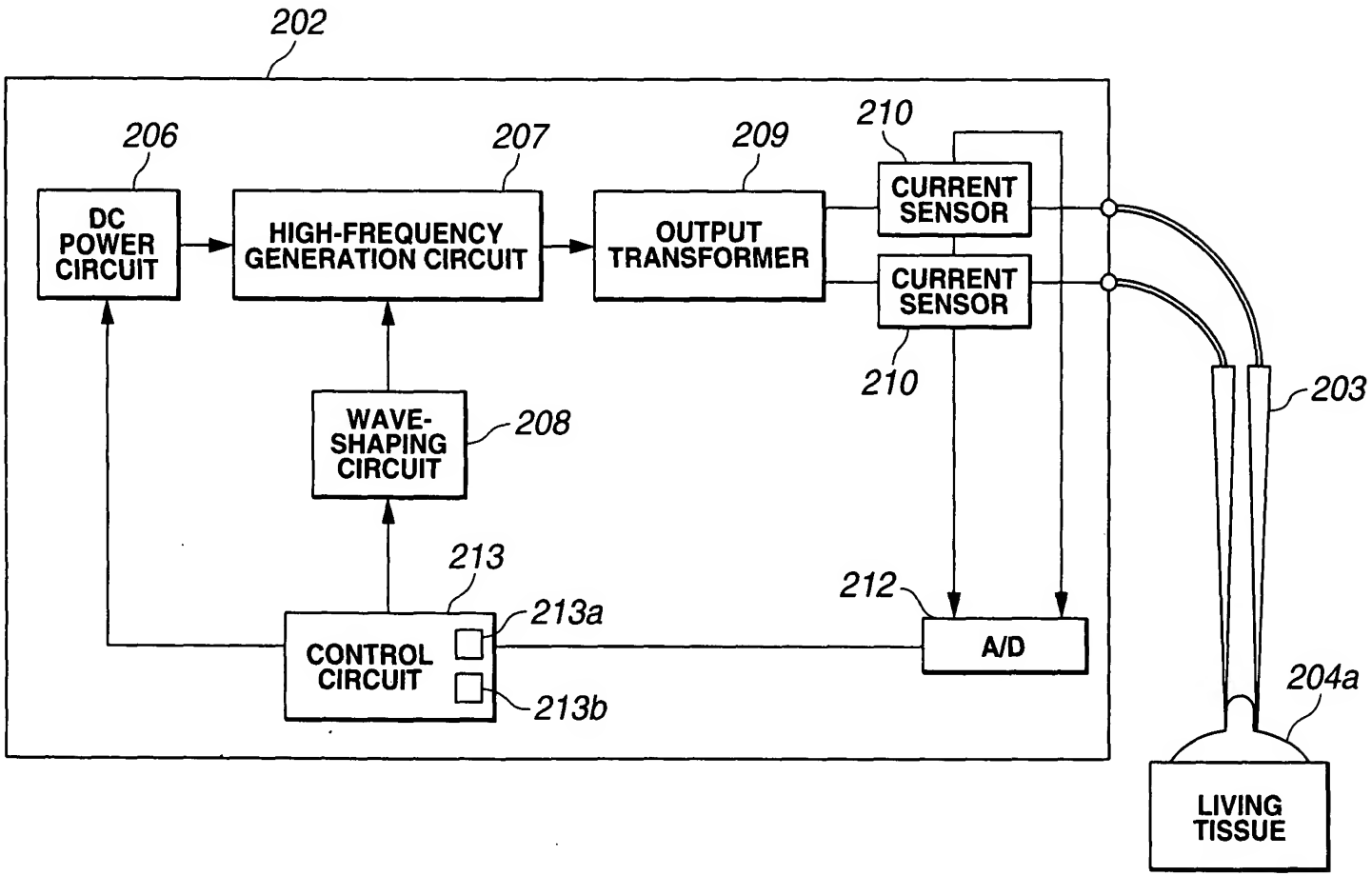

202
206
207
209
210
DC POWER CIRCUIT
HIGH-FREQUENCY GENERATION CIRCUIT
OUTPUT TRANSFORMER
CURRENT SENSOR
CURRENT SENSOR
210
203
WAVE-SHAPING CIRCUIT
208
213
212
213a
CONTROL CIRCUIT
A/D
213b
204a
LIVING TISSUE

FIG.47A

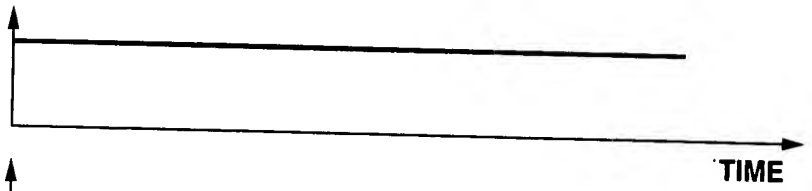


FIG.47B

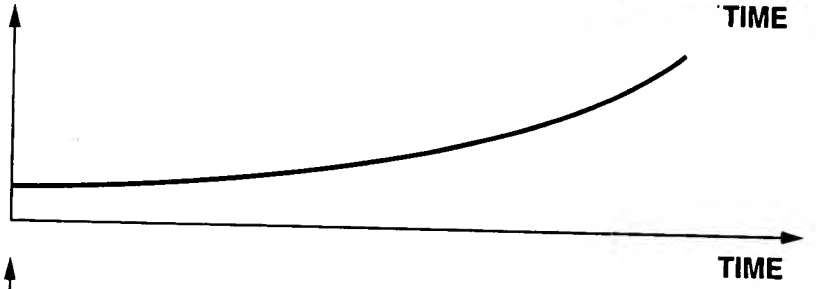


FIG.47C

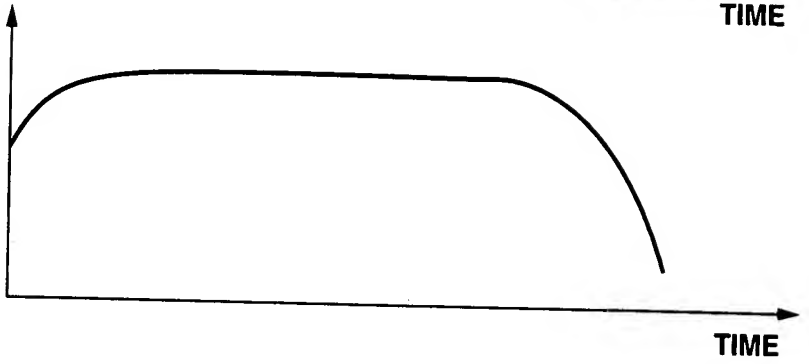


FIG.48A

FIG.48B

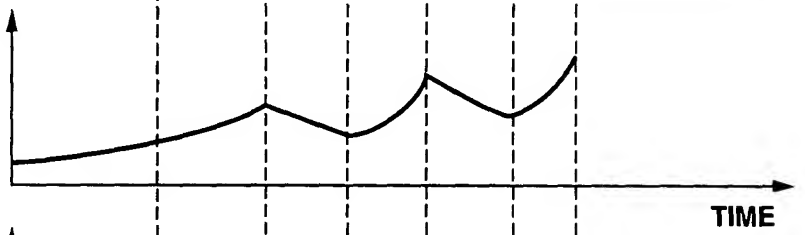


FIG.48C

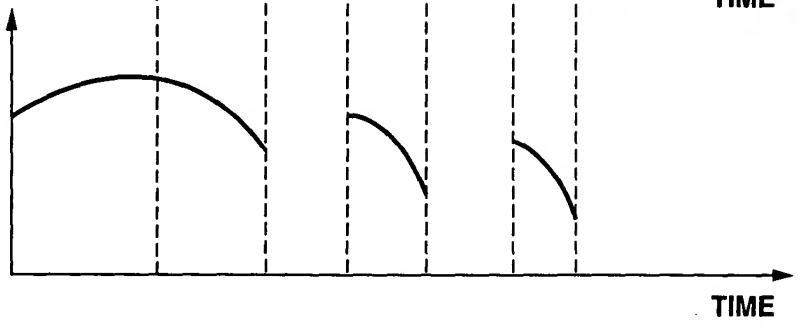


FIG.49A

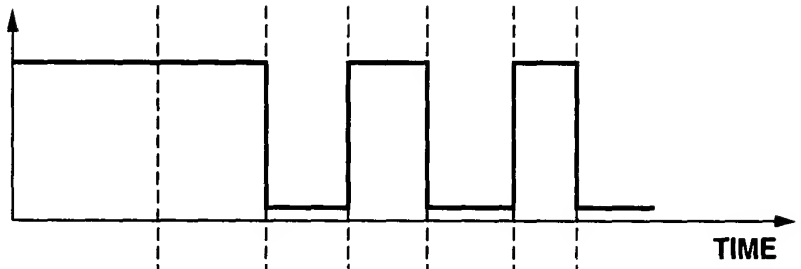


FIG.49B

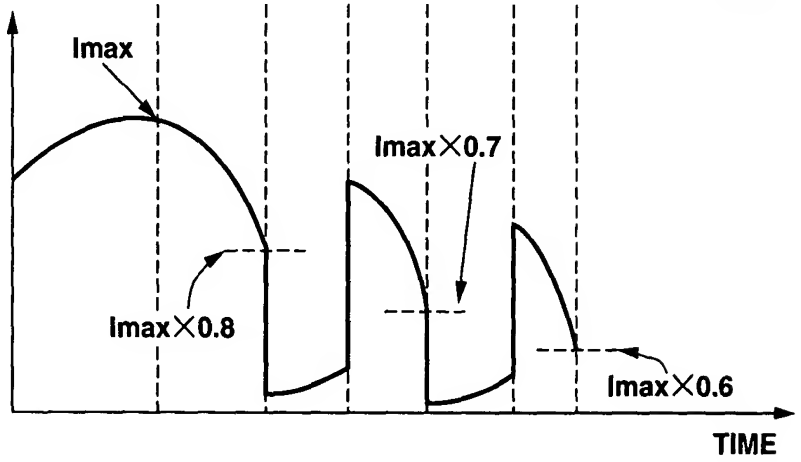


FIG.50A

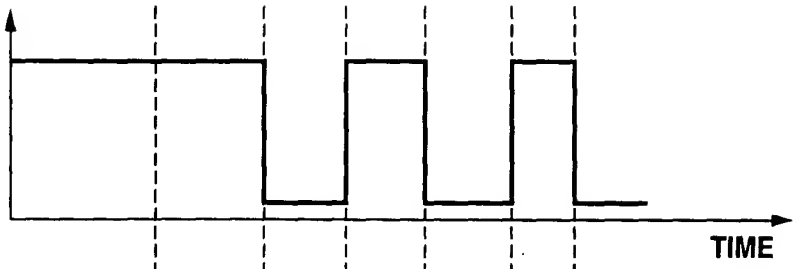


FIG.50B

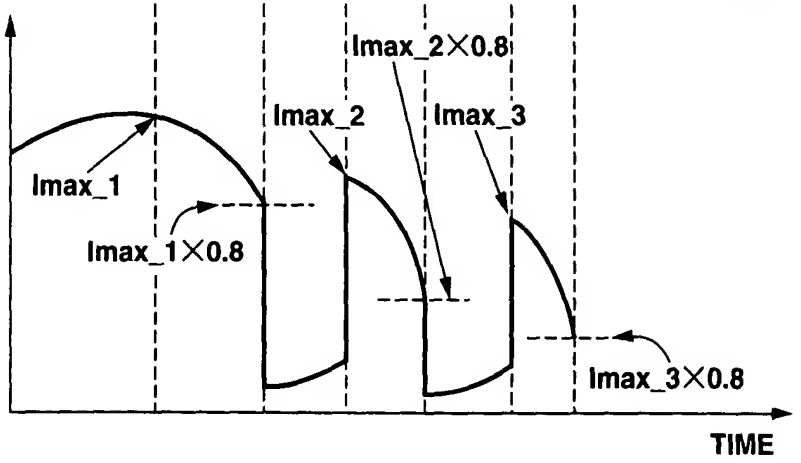


FIG.51A

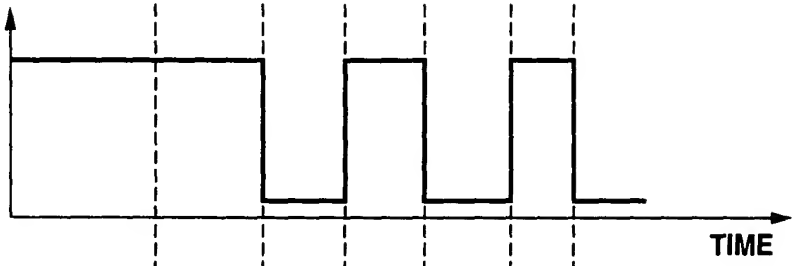


FIG.51B

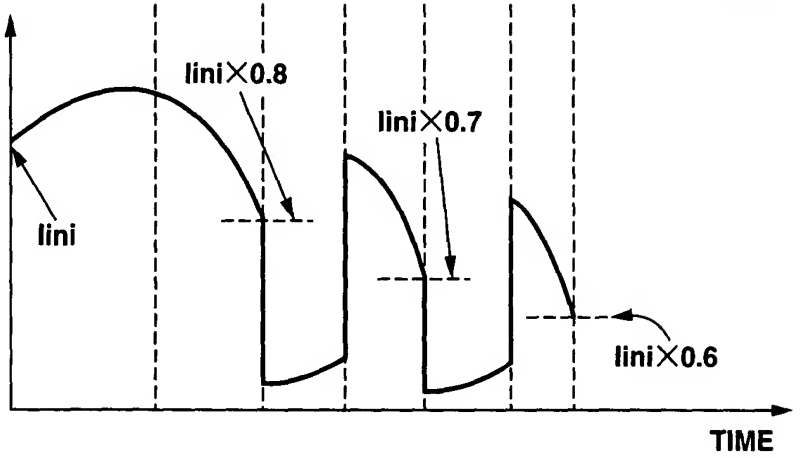


FIG.52A

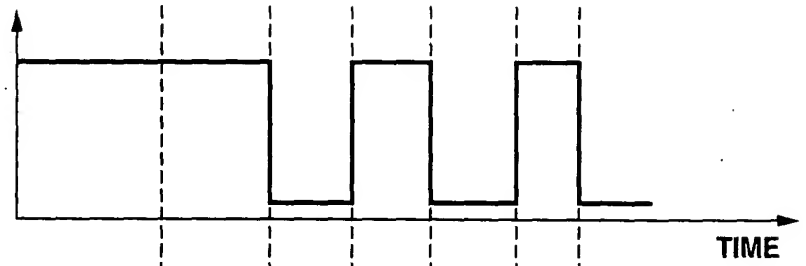
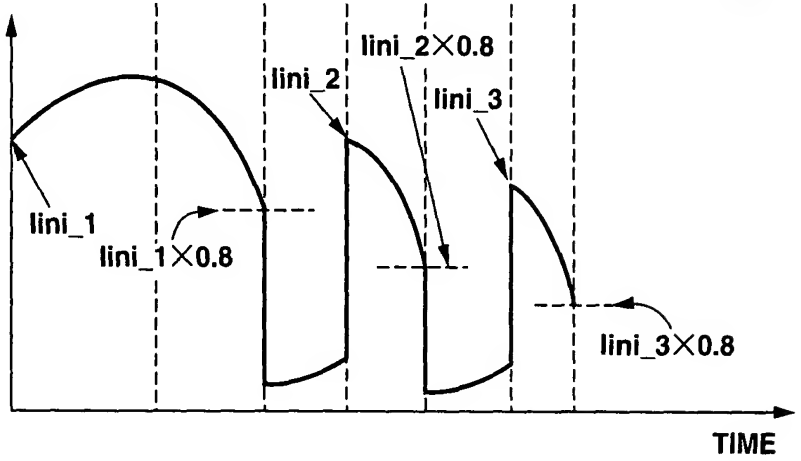



FIG.52B